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PULSE RATE, RESPIRATORY RATE, AND BODY TEMPERATURE OF CHILDREN BETWEEN TWO MONTHS AND EIGHTEEN YEARS OF AGE

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Child Research Council, University of Colorado, School of Medicine

Pulse rates, respiratory rates, and body temperature values have been obtained under uniform conditions on children of the Child Research Council at the time of the basal metabolism determinations (4). An analysis of these data is presented here since the literature has given inconsistent values for the range of pulse rate and body temperature of children and no range for the respiratory rate.

METHOD

The data for pulse rates, respiratory rates, and oral or rectal body temperatures were obtained on Child Research Council children immediately following the routine basal metabolism determinations (4). From 3 to 18 years of age the measurements were taken in the morning when the children were fasting, quiet, and apparently relaxed. On the other hand, from 2 to 18 months the heat production was obtained under sleeping, fed conditions at varying times during the day. In this group the pulse rates and body temperatures were measured as soon as the infants awakened after the completion of the test. The pulse rates were not taken while the children were asleep in the closed chamber because the necessary procedure was found to be too disturbing. The respiratory rates, however, were counted while the children slept quietly. From 18 months to 3 years, some of the measurements were made under these sleeping, fed circumstances, while more than half were obtained under the awake, fasting conditions described above for children from 3 to 18 years. At no time were values used for this analysis when there was any evidence of illness.

The pulse rates were obtained on the children by palpation of the wrist and on infants by the use of a stethoscope placed over the heart, or occasionally by palpation of the ankle. An effort was always made to find the lowest possible rate under the previously described conditions. The length of time the pulse was counted varied according to the cooperation of the subject, and was never less than 30 seconds. The respiratory rates were determined by observation of the subjects for at least half a minute.

TABLE 1

NUMBER OF TESTS, MEAN, STANDARD ERROR OF MEAN, AND STANDARD DEVIATION OF MEAN FOR PULSE RATES OF CHILD RESEARCH COUNCIL BOYS AND GIRLS FOR EACH YEAR OF AGE UP TO 18 YEARS*

	Pulse Rate per Minute					
	BOYS			GIRLS		
Age in Years	*No. of Tests*	*Mean* $\pm \sigma_m$	*Standard Deviation*	*No. of Tests*	*Mean* $\pm \sigma_m$	*Standard Deviation*
0– 1 ...	33	135 ± 3.1	18	56	126 ± 2.8	21
1– 2 ...	82	105 ± 1.8	16	93	104 ± 1.8	17
2– 3 ...	150	93 ± 1.0	12	177	93 ± 0.7	9
3– 4 ...	157	87 ± 0.7	9	145	89 ± 0.7	9
4– 5 ...	157	84 ± 0.7	8	137	84 ± 0.7	8
5– 6 ...	150	79 ± 0.6	7	129	79 ± 0.6	7
6– 7 ...	146	76 ± 0.6	8	122	77 ± 0.7	8
7– 8 ...	140	75 ± 0.7	8	117	76 ± 0.8	8
8– 9 ...	142	73 ± 0.7	9	114	73 ± 0.6	7
9–10 ...	168	70 ± 0.6	7	106	70 ± 0.7	8
10–11 ...	164	67 ± 0.6	7	98	69 ± 0.8	8
11–12 ...	129	67 ± 0.6	7	84	69 ± 0.8	7
12–13 ...	131	66 ± 0.6	7	72	69 ± 0.9	8
13–14 ...	110	65 ± 0.8	8	68	68 ± 0.9	8
14–15 ...	106	62 ± 0.7	7	57	66 ± 1.1	8
15–16 ...	76	61 ± 0.9	8	47	65 ± 1.1	8
16–17 ...	45	61 ± 0.9	6	30	66 ± 1.4	8
17–18 ...	38	60 ± 1.4	8	20	65 ± 1.7	7

* Measurements were made following the basal metabolism determinations and all those after three years were made in the morning.

Oral body temperatures were obtained on the children over 4 years and rectal body temperatures on the children under 3 years of age. Between 3 and 4 years, the method of measurement varied. The oral temperature determinations were made with a clinical thermometer which was held under the tongue with the lips closed firmly over the shaft for 3 minutes. A reading was taken and subsequently verified by returning the thermometer to the mouth for an additional minute. If necessary, this procedure was repeated until two readings were the same. From previous experience the authors found this was sufficient time to obtain a reliable oral temperature, and a study of De Nasaquo, Kerlan, Knudsen, and Klumpp (1) has

confirmed these observations. In order to obtain the rectal body temperatures of the children, a clinical thermometer was placed in the rectum for 4 minutes, then read.

From the data on pulse rate, respiratory rate, and body temperature, the mean, the standard error of the mean, and the standard deviation of the mean were calculated for boys and girls for each year up to 18 years. The tenth, fiftieth, and ninetieth percentiles were obtained for each age and sex from cumulative frequency distributions or ogives (5). From these values, plotted as rate or temperature against age, percentile curves were smoothed by inspection.

Results

There have been 2,124 determinations of pulse rate on 102 boys and 1,672 determinations on 95 girls between 2 months and 18 years of age. The number of tests, the mean, the standard error of the mean, and the standard deviation of the mean for each year are given in Table 1. The mean pulse rates of boys and girls decreased until about 15 years of age, after which they became almost constant. The greatest decrease occurred during the first two years of life at which time the variation from the mean was also greatest.

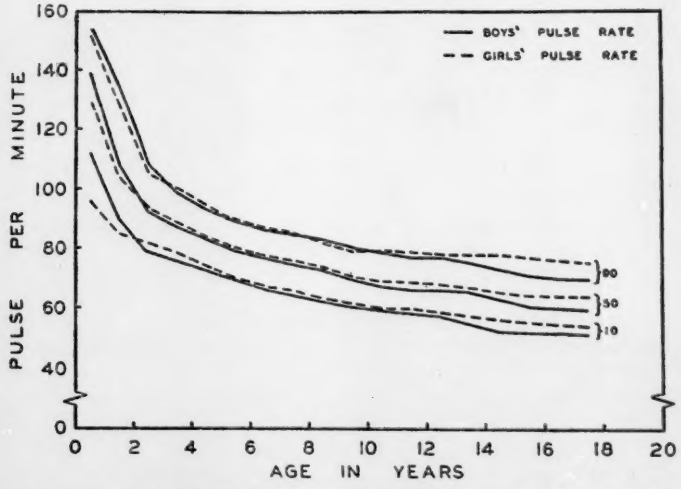

Figure 1—Tenth, fiftieth, and ninetieth smoothed percentile zones of pulse rates for Child Research Council children between 2 months and 18 years of age. Measurements were made following the basal metabolism determinations and all those after 3 years were made in the morning.

TABLE 2

NUMBER OF TESTS, MEAN, STANDARD ERROR OF MEAN, AND STANDARD DEVIATION OF MEAN FOR RESPIRATORY RATES OF CHILD RESEARCH COUNCIL BOYS AND GIRLS FOR EACH YEAR OF AGE UP TO 18 YEARS*

	Respiratory Rate per Minute					
	BOYS			GIRLS		
Age in Years	*No. of Tests*	*Mean* $\pm \sigma_m$	*Standard Deviation*	*No. of Tests*	*Mean* $\pm \sigma_m$	*Standard Deviation*
0– 1 ...	38	31 ± 1.3	8	55	30 ± 0.8	6
1– 2 ...	69	26 ± 0.5	4	79	27 ± 0.5	4
2– 3 ...	118	25 ± 0.4	4	134	25 ± 0.3	3
3– 4 ...	131	24 ± 0.2	3	119	24 ± 0.2	3
4– 5 ...	122	23 ± 0.2	2	113	22 ± 0.2	2
5– 6 ...	110	22 ± 0.2	2	100	21 ± 0.2	2
6– 7 ...	128	21 ± 0.2	3	97	21 ± 0.3	3
7– 8 ...	119	20 ± 0.2	3	97	20 ± 0.2	2
8– 9 ...	113	20 ± 0.2	2	101	20 ± 0.2	2
9–10 ...	141	19 ± 0.2	2	98	19 ± 0.2	2
10–11 ...	141	19 ± 0.2	2	90	19 ± 0.2	2
11–12 ...	123	19 ± 0.2	3	82	19 ± 0.3	3
12–13 ...	131	19 ± 0.2	3	72	19 ± 0.3	2
13–14 ...	110	19 ± 0.2	2	68	18 ± 0.3	2
14–15 ...	106	18 ± 0.2	2	57	18 ± 0.4	3
15–16 ...	76	17 ± 0.3	3	47	18 ± 0.4	3
16–17 ...	45	17 ± 0.4	2	30	17 ± 0.5	3
17–18 ...	38	16 ± 0.5	3	20	17 ± 0.7	3

* Measurements were made at the time of the basal metabolism determinations and all those after three years were made in the morning.

It is apparent from the large standard error of the mean that the data on pulse rates for the first 2 years were not as reliable as those at the older ages. Factors which tended to make these data less trustworthy were the small number of tests obtained during this period and the difficulty of keeping the children of this age under standard conditions of quiet and relaxation while the pulse was counted.

The mean pulse rates of boys and girls were approximately the same until 10 years of age. Between 10 and 15 years the pulse rates for boys decreased more rapidly than those for girls with the result that the mean rate for boys at 15 years was 5 beats per minute lower than that for girls. This difference remained the same up to 18 years.

The smoothed tenth, fiftieth, and ninetieth percentiles of pulse rates for boys and girls are presented in Figure 1. It can be seen that for either sex the percentile lines shown parallel each other. With 3 exceptions the yearly medians (fiftieth percentiles) and means for boys or for girls were within 2 pulse beats per minute of one another. The exceptions occurred at 1 and 2 years for boys and at 1 year for girls, when the differences were 3 or 4 beats per minute. These greater differences were additional evidence of the inadequacy of the data obtained during the first 2 years.

There have been 1,859 determinations of respiratory rate on 95 boys and 1,459 determinations on 93 girls from 2 months to 18 years. The number of tests, the mean, the standard error of the mean, and the standard deviation of the mean for each year are given in Table 2. The mean respiratory rates of boys and girls were approximately the same and showed a gradual decrease during the age period studied. The decrease during the first 2 years was more marked than at subsequent ages. With the exception of the first year, the range of variation was uniformly small.

The smoothed tenth, fiftieth, and ninetieth percentiles for respiratory rates for boys and girls are given in Figure 2. After the first two years the tenth and ninetieth percentiles of boys or girls were parallel to their respective median trend lines. The median values fell within one respiration per minute of the means for boys or girls.

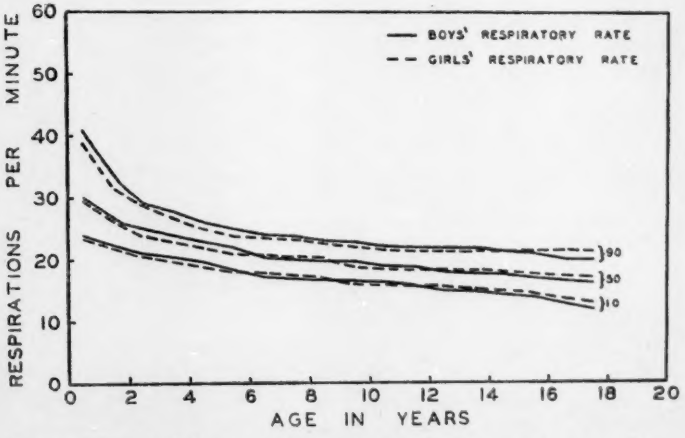

FIGURE 2—Tenth, fiftieth, and ninetieth smoothed percentile zones of respiratory rates for Child Research Council children between 2 months and 18 years of age. Measurements were made at the time of the basal metabolism determinations and all those after 3 years were made in the morning.

TABLE 3

NUMBER OF TESTS, MEAN, STANDARD ERROR OF MEAN, AND STANDARD DEVIATION OF MEAN FOR BODY TEMPERATURES OF CHILD RESEARCH COUNCIL BOYS AND GIRLS FOR EACH YEAR OF AGE UP TO 18 YEARS*

Age in Years	*Body Temperature* (°F.)					
	BOYS			GIRLS		
	No. of Tests	*Mean* $\pm \sigma_m$	*Standard Deviation*	*No. of Tests*	*Mean* $\pm \sigma_m$	*Standard Deviation*
0– 1 ...	38	R 99.1 ± 0.12	0.7	57	R 99.1 ± 0.05	0.4
1– 2 ...	86	R 99.1 ± 0.05	0.5	92	R 98.9 ± 0.05	0.5
2– 3 ...	145	R 99.0 ± 0.03	0.4	167	R 98.8 ± 0.03	0.4
3– 4 ...	96	R 98.9 ± 0.04	0.4	96	R 98.8 ± 0.04	0.4
3– 4 ...	59	98.7 ± 0.06	0.5	45	98.7 ± 0.08	0.5
4– 5 ...	116	98.6 ± 0.04	0.5	98	98.5 ± 0.06	0.5
5– 6 ...	141	98.5 ± 0.04	0.4	121	98.5 ± 0.04	0.4
6– 7 ...	144	98.4 ± 0.04	0.4	120	98.5 ± 0.04	0.4
7– 8 ...	141	98.3 ± 0.04	0.4	117	98.4 ± 0.04	0.4
8– 9 ...	142	98.3 ± 0.04	0.4	113	98.3 ± 0.03	0.4
9–10 ...	167	98.1 ± 0.04	0.5	106	98.2 ± 0.04	0.4
10–11 ...	163	98.0 ± 0.04	0.5	98	98.1 ± 0.04	0.4
11–12 ...	129	98.0 ± 0.03	0.4	84	98.0 ± 0.05	0.5
12–13 ...	131	97.8 ± 0.04	0.4	71	97.9 ± 0.05	0.4
13–14 ...	110	97.7 ± 0.04	0.4	68	97.9 ± 0.06	0.5
14–15 ...	106	97.6 ± 0.04	0.4	57	97.9 ± 0.08	0.6
15–16 ...	76	97.4 ± 0.05	0.4	47	97.9 ± 0.06	0.4
16–17 ...	45	97.3 ± 0.07	0.5	30	97.8 ± 0.09	0.5
17–18 ...	38	97.2 ± 0.06	0.4	20	97.9 ± 0.12	0.5

* Measurements were made following the basal metabolism determinations and all those after three years were made in the morning. Temperatures measured rectally are indicated by the letter "R"; other temperatures were taken orally.

There have been 365 determinations of rectal body temperature on 60 boys and 412 determinations on 69 girls between 2 months and 4 years, as well as 1,708 measurements of oral body temperature on 94 boys and 1,195 determinations on 78 girls between 3 and 18 years of age. The number of tests, the mean, the standard error of the mean, and the standard deviation of the mean for each year are given in Table 3. From 1 to 13 years of age, the mean body temperatures of boys and girls decreased. During this time, the mean temperatures of the boys were always within 0.1°F. of those of the girls. After 13 years the temperatures of the boys continued to decrease

and those of the girls remained nearly constant with the result that by 17 years the difference between the means amounted to 0.7°F.

In Figure 3 are given the smoothed tenth, fiftieth, and ninetieth percentiles for oral and rectal body temperature determinations of boys and girls. The results are expressed in degrees Fahrenheit as well as in degrees Centigrade. For the most part, the tenth and ninetieth percentiles for boys and girls parallel their respective median trend lines. The difference between the yearly medians and means for boys or girls was never more than 0.1°F.

Discussion

Since the oral temperatures, particularly those of the older children, were lower than might have been anticipated, an attempt was made to find an explanation for this. There were several factors in the procedure which undoubtedly had some influence on the body temperature, such as the time of day, the amount of activity, the length of exposure to varying outdoor temperatures and the length of rest period during the basal metabolism test.

The usual procedure was to pick up the children at home shortly after they had arisen, which was usually between 7 and 8 a.m. An effort had been made in the various homes to keep the children's activity at a minimum. It required from 5 to 30 minutes to drive from the different homes to the

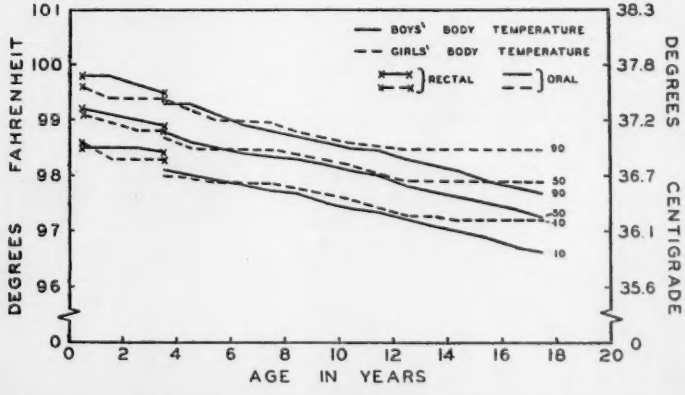

Figure 3—Tenth, fiftieth, and ninetieth smoothed percentile zones of body temperatures, expressed in degrees Fahrenheit and degrees Centigrade, for Child Research Council children between 2 months and 18 years of age. Measurements were made following the basal metabolism determinations and all those after 3 years were made in the morning.

laboratory. As mentioned previously, the oral body temperatures were taken at the completion of the basal metabolism determinations when the children had been lying quietly for about 40 minutes. In order to ascertain what body temperature changes took place during the basal metabolism tests, the temperatures were measured immediately after the children entered the chamber as well as at the end of the tests. This latter procedure was done for one year.

During the approximate 40 minutes of the basal metabolism test, the children showed a change in body temperature which ranged from —0.3 to +2.9°F. Only 3 of the changes were greater than +2.0°F. and 11 were between +1.5 and +2.0°F. No correlation was found between the changes in body temperature and the outdoor temperatures at the time the children were brought to the laboratory. Furthermore, no consistent relationship was apparent between the body temperature change and the age, sex, or basal metabolic rate of the children.

It is probable that the increase in oral body temperature found in 165 of the 185 measurements on 96 children was part of the well-known diurnal rise which occurs upon awakening. Kleitman and Ramsaroop (3) made extensive studies of this diurnal fluctuation in body temperature and reported that the rate of increase, the maximum temperature attained, and the time of day at which the maximum temperature occurred varied with the individual. Eighteen Child Research Council children, on whom there were 20 measurements, failed to show this increase in body temperature during the basal metabolism test. Nothing could be found that was characteristic of these particular children nor of the situation on the day of the test which might account for this lack of increase. In fact, 16 of the 18 children who showed at one time either a decrease in body temperature or no change did show an increase at some other time. The other 2 children were seen only once during the year this procedure was followed. The decrease or lack of change in oral temperature shown by these individuals may be compared with the fall in body temperature found by Kleitman and Doktorsky (2) in subjects who assumed a horizontal position after they had been standing for an hour. These authors suggest that this drop may have been due to a desreased muscle tonus. In the present study when the children showed no change or a decrease in body temperature, they may have been more active than was customary before the basal metabolism test so that there was a greater decrease than usual in their muscle tonus during the test.

In regard to the standards given here, it should be emphasized that the measurements of pulse rate, respiratory rate, and oral or rectal body temperature were obtained under conditions of quiet and relaxation. Furthermore, after 3 years of age the measurements were made early in the morning. Both of these factors were instrumental in producing results lower than one might find under many other circumstances.

Summary

Measurements of pulse rate, respiratory rate, and rectal or oral body temperature were made on children between 2 months and 18 years of age at the time of basal metabolism determinations.

These data consist of 2,124 determinations of pulse rate on 102 boys and 1,672 on 95 girls, 1,859 measurements of respiratory rate on 95 boys and 1,459 on 93 girls, and 2,073 observations of either rectal or oral body temperature on 102 boys and 1,607 on 95 girls.

From these data, the means, the standard errors of the means, the standard deviations of the means, the smoothed tenth, fiftieth, and ninetieth percentiles were computed for each year of age.

In general, the pulse rates, respiratory rates and body temperatures of the children decreased during the age period studied. The decrease was greatest during the first 2 years for pulse rate and respiratory rate. No such difference in the rate of decrease was found in body temperature during this age period.

The mean pulse rates for boys and girls were approximately the same until 10 years of age, after which the rates for boys became lower than those for girls. The mean body temperatures for boys and girls were about the same until 13 years of age. After this age, the temperatures for boys continued to decrease gradually while the temperatures for girls remained stationary. There was almost no difference between the mean respiratory rates for boys and girls.

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A METHOD OF EVALUATING OSSEOUS DEVELOPMENT FROM BIRTH TO 14 YEARS [1]

VERNETTE S. VICKERS HARDING

In 1930 the Department of Maternal and Child Health of the School of Public Health, Harvard University, initiated a study of the growth and development of a group of well children.[2] The purposes, methods, and scope of this study have been described in detail in a publication by the Director, Dr. Harold C. Stuart.[3]

The 323 white children enrolled in this study were born to women who had been selected from the prenatal clinics of the Boston Lying-in Hospital. The parents of these children represent the average "middle class" family; approximately 90 per cent of them are of North European stock.

These children were examined at three-month intervals from birth through eighteen months and thereafter at six-month intervals until 1943 when yearly examinations were instituted. All examinations were given within a specified number of days of the age represented, the allowable time variation increasing with age. The periodic visits of the children included pediatric, psychometric, and orthopedic examinations, nutritional and health histories, blood and urine analyses, and anthropometric measurements. At these visits the children were X-rayed and photographed.

The X-ray photographs, of which there are more than 5000 complete sets, or approximately 50,000 films, were examined for pathology by a roentgenologist. The author noted the appearance and development of the bones and their epiphyses. This paper gives in detail the findings in regard to the appearance of most of the osseous centers and offers a simple method of rating osseous development in children from birth to 14 years of age.

Figure 1 shows the centers which are the bases for this method. An osseous center is called present if it is at least 2 mm. in diameter. Exceptions are the epiphyses of the long bones of the hand and foot. These centers often can be seen distinctly when less than 2 mm. in diameter. No twins or prematures are included in the compilation of the osseous centers which appear

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[1] From the Department of Maternal and Child Health, School of Public Health, Harvard University, Boston, Massachusetts.

[2] This study was made possible during the early years by a grant from the General Education Board of the Rockefeller Foundation, and more recently by one from the James Foundation of New York City.

[3] Stuart, H. C. and Staff. Studies from the Center for Research in Child Health and Development, School of Public Health, Harvard University. I. The Center, the group under observation, sources of information, and studies in progress. *Monogr. Soc. Res. Child Develpm.*, Vol. IV, No. 1, 1939.

during the first five years but data from these two groups of children are included thereafter.

Tables 1, 2, 3, and 4 indicate the percentage of children having a particular center at each age. It will be observed that the girls are ahead of the boys in the appearance of the osseous centers. This difference is present at birth as well as at subsequent ages.

Tables 5, 6, and 7 show the range for the appearance of certain osseous centers. The middle two columns, which are the 25th and 75th percentiles, indicate the ages between which the middle 50 per cent of the children fall. The two outside columns are the 10th and 90th percentiles or are the ages between which 80 per cent of the children are found. If a child is found outside the range of the middle 80 per cent it may be assumed that he is either retarded or advanced.

Tables 8 and 9 offer a simple method of estimating osseous development between the ages of birth and 14 years. This chart is particularly useful if the same child is to be examined periodically. To use this chart[4] the horizontal column nearest the child's chronological age is selected and all the centers which are present (2 mm. or larger) are underlined. It is advantageous in the ultimate reading of the table if a contrasting color is used. If there is no view of a particular center its name should be crossed out on the chart in order that this center does not influence the rating by appearing to be absent. The vertical category in which half or more of the expected centers are present is the one which represents the child's osseous development. The absence of a center in a low category should be ignored if the majority of the centers are present in the next higher grouping. Likewise, the presence of a center or centers in a category much above the rating should be disregarded.

A chart similar to Table 8 or 9 is kept for each child. At each examination the chart is filled in opposite the appropriate age. This offers a simple method for rapid estimation of a child's osseous development. The same chart used at repeated examinations has the advantage of showing whether a child is maintaining his previous rate of development, falling behind, or is accelerating.

An analysis of the osseous ratings over long periods of time show that the children in this study maintained a comparatively constant rate of developement. Eighty-seven children had osseous ratings at birth, 2, 4, 6, 8, and 10 years. Thirty-two of these also were rated at 12 years and 43 of them had a rating at 14 years. Table 10 shows the percentage of children who received the same rating, or a rating either one category above or one category below, from one age period to another.

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[4] The chart used in Tables 8 and 9 has been modified somewhat in order to make it possible to reproduce the material within limits of page size. This modification consisted in reversing the vertical and horizontal direction of the age and developmental category columns. (Editors' note)

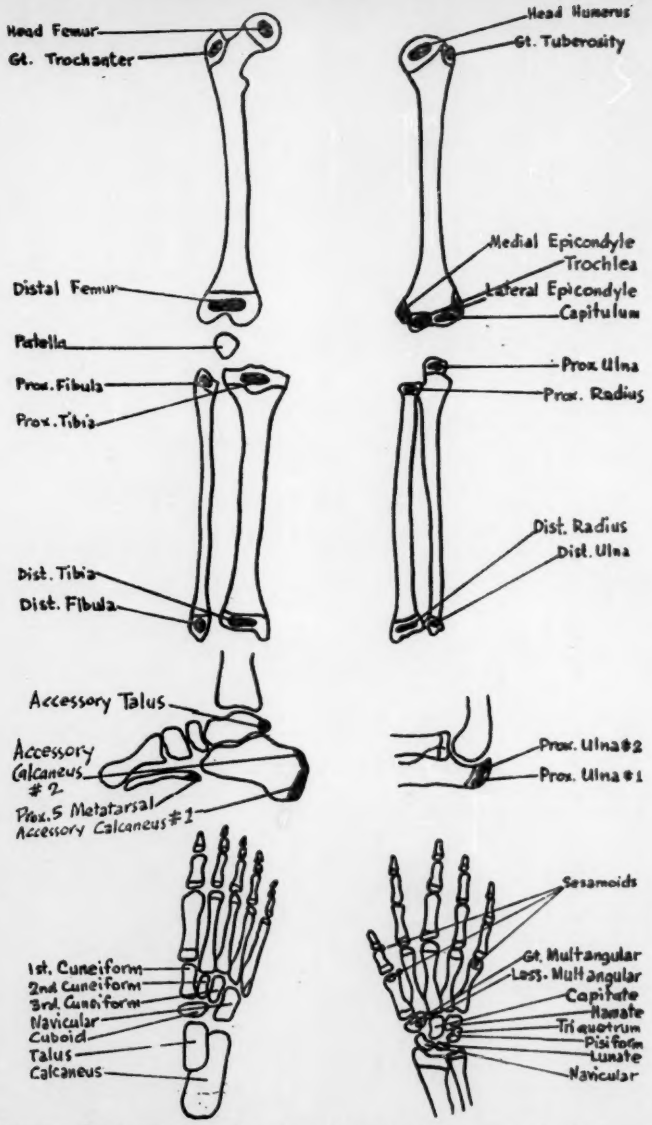

FIGURE 1—Bone centers used as bases for evaluating osseous development.

Table 1

PERCENTAGE OF OSSEOUS CENTERS IN A GROUP OF BOYS FROM BIRTH TO 14 YEARS

	Birth	2 wks.	6 wks.	3 mos.	6 mos.	9 mos.	12 mos.	15 mos.	18 mos.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.
Calcaneus	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Talus	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Femur	93	97	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Prox. Tibia	60	84	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cuboid	23	48	77	90	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hd. Humerus	19	46	71	90	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Capitate	4	10	19	50	94	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hamate	5	9	13	38	83	94	96	99	99	100	..	..	..	..	..	..	..	..	..	..	..	..
Coracoid	11	11	20	44	71	87	93	93	98	98	99	99	100	..	..	..	..	..	..	..	..	..
3rd Cuneiform	1	2	8	37	72	87	90	97	98	99	100	..	..	..	..	..	..	..	..	..	..	..
Hd. Femur	..	..	1	14	77	98	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Tibia	..	..	..	13	77	97	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Capitulum	1	1	1	14	63	80	84	92	94	98	99	99	100	..	..	..	..	..	..	..	..	..
Gt. Tuber. Humerus	..	..	..	..	11	31	54	78	82	88	97	99	100	..	..	..	..	..	..	..	..	..
Dist. Radius	..	..	..	..	4	24	46	72	76	91	98	99	100	..	..	..	..	..	..	..	..	..
Dist. Fibuia	..	..	..	..	3	14	44	74	81	93	100	..	..	..	..	..	..	..	..	..	..	..
1st Cuneiform	..	..	..	..	2	8	12	20	27	42	86	97	100	..	..	..	..	..	..	..	..	..
2nd Cuneiform	..	..	..	..	1	4	7	7	13	26	71	96	99	100	..	..	..	..	..	..	..	..
Navicular (foot)	..	..	..	..	1	2	3	4	9	23	56	76	92	100	..	..	..	..	..	..	..	..
Triquetrum	..	..	..	..	8	11	17	21	28	37	65	82	96	99	99	100	..	..	..	..	..	..
Lunate	..	..	..	..	..	..	2	4	4	13	35	55	73	91	97	100	..	..	..	..	..	..
Gt. Troch. Femur	..	..	..	..	..	..	..	..	..	1	19	68	93	99	100	..	..	..	..	..	..	..
Patella	..	..	..	..	..	..	..	..	..	..	12	46	77	92	99	100	..	..	..	..	..	..
Prox. Fibula	..	..	..	..	..	..	..	..	..	2	21	54	80	96	100	..	..	..	..	..	..	..
Navicular (hand)	..	..	..	..	..	..	..	..	..	..	1	6	23	50	77	97	100	..	..	..	..	..

Gt. Multangular	..	..	..	..	..	..	..	..	..	..	2	7	24	43	71	87	94	99	100	..	..	..
Less. Multangular	..	..	..	..	..	..	..	..	..	..	2	7	26	48	75	90	100	..	..	..	..	..
Prox. Radius	..	..	..	..	..	..	..	..	..	..	1	11	34	56	81	96	98	100	..	..	..	..
Med. Epicondyle Hum	..	..	..	..	..	..	..	..	..	..	..	3	12	30	52	79	96	98	100.	..	..	..
Dist. Ulna	..	..	..	..	..	..	..	..	..	..	..	..	1	13	45	75	93	98	100	..	..	..
Accessory Calcaneus (1)	..	..	..	..	..	..	..	..	..	..	..	..	1	5	16	61	84	99	99	100	..	..
Epiphysis Talus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	20	50	91	98	100	..
Trochlea, Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	8	26	52	83	97	100	..
Prox. Ulna (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	4	18	47	84	96	100	..
Pisiform	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	2	11	24	49	80	97	100
Lat. Epicondyle Hum	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	29	62	91	100
Epiphysis Base Metat. V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	3	14	37	67	95
Sesamoid Metac. I (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	7	28	56	87
Prox. Ulna (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	22	55	81
Accessory Calcaneus (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	11	27	56	79
Sesamoid Metac. I (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	12	25	55
Sesamoid Dist. Metac. V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	9	28
Sesamoid Thumb Interphal	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	17
Fusion																						
Talus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	11	47	72	89	95
Metatarsal V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	20	49
Trochlea, Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	36
Lat. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	20
Med. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Prox. Ulna (1 and 2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
Prox. Radius	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
Dist. Radius	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Dist. Ulna	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Calcaneus (1 and 2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8
Dist. Tibia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4
No. Cases	136	94	92	114	112	111	121	110	114	112	116	112	108	104	99	94	90	72	63	60	57	48

Table 2

PERCENTAGE OF OSSEOUS CENTERS IN A GROUP OF GIRLS FROM BIRTH TO 14 YEARS

	Birth	2 wks.	6 wks.	3 mos.	6 mos.	9 mos.	12 mos.	15 mos.	18 mos.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.
Calcaneus	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Talus	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Femur	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Prox. Tibia	66	91	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cuboid	44	71	93	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hd. Humerus	24	55	87	97	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Capitate	7	18	33	68	96	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Hamate	7	16	28	56	91	99	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3rd Cuneiform	1	6	14	53	78	89	95	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..
Coracoid	9	13	23	53	80	92	97	98	99	99	99	100	..	..	..	..	..	..	..	..	..	..
Hd. Femur	..	..	2	35	91	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Tibia	..	..	..	19	89	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Capitulum	..	..	..	39	87	96	98	99	100	..	..	..	..	..	..	..	..	..	..	..	..	..
Gt. Tuber. Humerus	..	..	..	4	47	85	94	99	99	99	100	..	..	..	..	..	..	..	..	..	..	..
Dist. Fibula	..	..	..	..	9	48	82	97	98	100	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Radius	..	..	..	..	9	42	68	90	93	98	100	..	..	..	..	..	..	..	..	..	..	..
1st Cuneiform	..	..	..	..	2	14	32	57	71	85	100	..	..	..	..	..	..	..	..	..	..	..
2nd Cuneiform	..	..	..	..	3	7	13	22	38	73	99	100	..	..	..	..	..	..	..	..	..	..
Navicular (foot)	..	..	..	..	..	4	13	22	25	58	87	99	100	..	..	..	..	..	..	..	..	..
Triquetrum	..	..	..	..	7	15	22	27	30	49	83	97	100	..	..	..	..	..	..	..	..	..
Lunate	..	..	..	..	1	1	3	7	9	23	51	85	94	98	100	..	..	..	..	..	..	..
Gt. Troch. Femur	..	..	..	..	..	..	..	..	3	24	81	99	100	..	..	..	..	..	..	..	..	..
Patella	..	..	..	..	..	..	..	1	2	20	77	91	99	100	..	..	..	..	..	..	..	..
Prox. Fibula	..	..	..	..	..	..	..	1	3	20	57	82	99	99	100	..	..	..	..	..	..	..
Navicular (hand)	..	..	..	..	..	..	..	..	..	1	9	39	69	93	100	..	..	..	..	..	..	..

Gt. Multangular	..	..	..	..	..	..	..	..	..	3	17	39	67	91	99	100	..	..	..	..	..	..
Less. Multangular	..	..	..	..	..	..	..	..	..	..	10	33	80	96	100	..	..	..	..	..	..	..
Med. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	2	23	63	82	96	98	100	..	..	..	..	..	..
Prox. Radius	..	..	..	..	..	..	..	..	..	..	11	39	71	87	96	98	100	..	..	..	..	..
Accessory Calcaneus (1)	..	..	..	..	..	..	..	..	..	..	1	6	38	79	93	100	..	..	..	..	..	..
Dist. Ulna	..	..	..	..	..	..	..	..	..	..	..	3	14	52	81	98	100	..	..	..	..	..
Prox. Ulna (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	2	14	49	85	99	100	..	..	..
Epiphysis Talus	..	..	..	..	..	..	..	..	..	..	..	..	..	2	10	37	82	94	99	100	..	..
Pisiform	..	..	..	..	..	..	..	..	..	..	..	..	..	2	15	38	68	88	99	100	..	..
Trochlea, Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	5	13	32	52	83	95	100	..	..
Lat. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	28	67	91	100	..	..
Epiphysis Base Metat. V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	20	47	74	93	100	..
Sesamoid Metac. I (1)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	7	35	68	93	100	..
Prox. Ulna (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	6	26	49	84	92	100
Accessory Calcaneus (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	13	39	73	90	100
Sesamoid Metac. I (2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	5	27	64	92	98
Sesamoid Dist. Metac. V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	20	55	80
Sesamoid Thumb Interphal	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	21	45	71
Fusion																						
Talus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	50	79	93	100	..	..
Metatarsal V	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	21	61	85	96
Trochlea, Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	46	85	100
Lat. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	31	65	92
Med. Epicondyle Humerus	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	6	28	63
Prox. Ulna (1 and 2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8	35	70
Prox. Radius	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	35	68
Dist. Ulna	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3
Dist. Radius	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
Calcaneus (1 and 2)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	20	50
Dist. Tibia	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	22	47
No. Cases	137	99	82	119	121	120	130	119	123	172	122	118	113	108	111	94	86	81	64	56	54	40

Table 3

PERCENTAGE OF OSSEOUS CENTERS OF THE HAND IN A GROUP OF BOYS AND GIRLS FROM BIRTH TO 14 YEARS

		6 mos.		9 mos.		12 mos.		18 mos.		2 yrs.		3 yrs.		4 yrs.		5 yrs.		6 yrs.		7 yrs.	
		B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Metacarpals	1	..	..	..	1	1	8	7	51	25	89	72	100	92	..	98	..	100	..	..	..
	2	1	..	1	12	6	46	47	92	83	100	100	..	..	..	..	..	..	..	..	..
	3	..	..	1	7	6	35	33	84	74	99	95	100	99	..	100	..	..	..	..	..
	4	..	..	..	2	1	18	22	79	58	97	92	100	99	..	100	..	..	..	..	..
	5	..	..	..	1	2	10	14	68	47	94	86	100	98	..	100	..	..	..	..	..
Phalanges																					
Proximal	1	..	..	..	..	..	4	1	36	14	84	63	99	93	100	99	..	100	..	..	..
	2	1	3	5	35	19	75	68	100	93	..	100	..	..	..	..	..	..	..	..	..
	3	1	6	6	44	21	79	76	100	94	..	100	..	..	..	..	..	..	..	..	..
	4	1	5	4	32	13	77	62	99	90	100	100	..	..	..	..	..	..	..	..	..
	5	..	..	2	4	2	27	24	86	63	99	96	100	100	..	..	..	..	..	..	..
Middle	2	..	..	..	2	2	26	14	71	52	97	91	100	100	..	..	..	..	..	..	..
	3	..	2	1	9	3	34	23	80	59	97	93	100	100	..	..	..	..	..	..	..
	4	..	2	..	9	2	38	20	81	57	98	93	100	100	..	..	..	..	..	..	..
	5	..	1	..	2	..	6	2	29	5	66	39	94	70	100	90	..	99	..	100	..
Distal	1	1	6	5	29	11	61	48	93	79	100	98	..	100	..	..	..	..	..	..	..
	2	..	..	..	..	..	2	1	21	4	62	38	97	86	100	96	..	99	..	100	..
	3	..	..	..	2	1	14	6	60	25	89	87	100	99	..	100	..	..	..	..	..
	4	..	..	..	2	..	12	5	54	22	97	85	100	98	..	100	..	..	..	..	..
	5	..	..	..	..	..	2	1	21	4	61	40	98	84	100	95	..	99	..	100	..

Table 4

PERCENTAGE OF OSSEOUS CENTERS OF THE FOOT IN A GROUP OF BOYS AND GIRLS FROM BIRTH TO 14 YEARS

		6 mos.		9 mos.		12 mos.		18 mos.		2 yrs.		3 yrs.		4 yrs.		5 yrs.		6 yrs.		7 yrs.		8 yrs.	
		B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G	B	G
Metatarsals																							
	1	..	..	1	..	1	2	5	45	32	95	85	100	99	..	100	..	..	..	..	..	..	..
	2	..	..	..	..	..	1	..	13	5	58	59	96	90	100	99	..	100	..	..	..	..	..
	3	..	..	..	..	..	..	..	4	..	23	23	88	74	97	95	100	100	..	..	..	..	..
	4	..	..	..	..	..	..	..	1	..	5	5	68	52	95	88	100	99	..	100	..	..	..
	5	..	..	..	..	..	..	..	..	..	1	2	48	27	85	73	99	93	99	100	100	..	..
Phalanges																							
Proximal	1	..	..	..	..	..	5	2	51	20	94	89	100	99	..	100	..	..	..	..	..	..	..
	2	..	2	1	9	5	45	35	90	67	99	100	100	..	..	..	..	..	..	..	..	..	..
	3	..	3	1	23	9	65	42	94	80	99	99	100	100	..	..	..	..	..	..	..	..	..
	4	..	3	1	17	7	58	34	92	74	98	99	100	100	..	..	..	..	..	..	..	..	..
	5	..	..	..	2	..	6	1	45	21	82	77	100	98	..	100	..	..	..	..	..	..	..
Middle*		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Distal	1	1	11	5	57	22	87	76	98	96	100	100	..	..	..	..	..	..	..	..	..	..	..
	2	..	..	..	..	..	..	..	..	..	5	3	58	21	89	52	98	88	100	98	..	100	..
	3	..	..	..	..	..	1	..	3	..	11	5	66	32	96	70	98	92	100	100	..	..	..
	4	..	..	..	..	..	1	..	4	..	23	6	77	32	96	72	99	92	100	100	..	..	..
	5*	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

* Epiphyseal centers for these phalanges are absent in a large percentage of children.

Table 5

RANGE IN TIME OF APPEARANCE OF OSSEOUS CENTERS

(Ages given in years and months except as indicated)

BOYS					GIRLS			
Range of Middle					Range of Middle			
80 Percent					80 Percent			
50 Percent					50 Percent			
-	-	-	Birth	Calcaneus	-	-	-	Birth
-	-	-	Birth	Talus	-	-	-	Birth
-	-	-	Birth	Dist. Femur	-	-	-	Birth
Birth	Birth	2 Wks.	4 Wks.	Prox. Tibia	-	Birth	1 Wk.	2 Wks.
Birth	1 Wk.	6 Wks.	0-3	Cuboid	-	Birth	3 Wks.	6 Wks.
Birth	1 Wk.	8 Wks.	0-3	Hd. Humerus	Birth	1 Day	5 Wks.	8 Wks.
3 Wks.	8 Wks.	0-5	0-6	Capitate	1 Wk.	4 Wks.	0-4	0-6
4 Wks.	9 Wks.	0-6	0-8	Hamate	1 Wk.	5 Wks.	0-5	0-6
7 Wks.	10 Wks.	0-7	0-12	3rd Cuneiform	5 Wks.	8 Wks.	0-6	0-10
Birth	7 Wks.	0-7	0-10	Coracoid	1 Wk.	7 Wks.	0-6	0-9
11 Wks.	0-4	0-6	0-8	Hd. Femur	8 Wks.	11 Wks.	0-5	0-6
11 Wks.	0-4	0-6	0-8	Dist. Tibia	8 Wks.	0-4	0-5	0-7
11 Wks.	0-4	0-8	0-11	Capitulum	8 Wks.	10 Wks.	0-5	0-7
0-6	0-9	1-5	2-1	Gt. Tuber. Hum.	0-4	0-5	0-8	0-10
0-9	0-11	1-6	1-11	Dist. Fibula	0-7	0-8	1-0	1-2

0-7	0-10	1-6	2-0	Dist. Radius	0-7	0-8	1-2	1-4
0-10	1-5	2-9	3-4	1st. Cuneiform	0-8	0-11	1-8	2-4
1-4	2-0	3-2	3-9	2nd. Cuneiform	0-11	1-4	2-1	2-8
1-7	2-1	4-0	4-10	Navicular (foot)	1-0	1-5	2-7	3-3
0-9	1-5	3-7	4-7	Triquetrum	0-7	1-3	2-9	3-6
1-11	2-7	5-1	5-11	Lunate	1-7	2-1	3-8	4-6
2-7	3-2	4-4	4-10	Gt. Tr. Femur	1-8	2-1	2-11	3-6
2-11	3-5	4-11	5-10	Patella	1-9	2-1	3-0	3-11
2-5	3-1	4-9	5-7	Prox. Fibula	1-9	2-2	3-9	4-4
4-3	5-1	6-11	7-8	Navicular (hand)	3-1	3-7	5-3	5-10
4-3	5-1	7-3	8-4	Gt. Multangular	2-7	3-6	5-4	6-0
4-3	5-0	7-0	8-0	Less. Multangular	3-1	3-8	4-10	5-8
4-11	5-10	7-10	8-8	Med. Epicondyle Hum.	2-6	3-1	4-7	5-7
4-0	4-7	6-9	7-7	Prox. Radius	3-0	3-6	5-3	6-3
6-6	7-3	8-7	9-5	Accessory Calcaneus #1	4-2	4-8	5-11	6-10
5-11	6-5	8-0	8-10	Dist. Ulna	4-9	5-3	6-10	7-6
8-7	9-3	10-9	11-7	Prox. Ulna #1	6-9	7-3	8-9	9-4
8-4	9-2	10-7	11-0	Epiphysis Talus	7-1	7-5	8-10	9-7
9-0	10-1	11-10	12-7	Pisiform	6-7	7-5	9-5	10-3
8-2	9-0	10-9	11-6	Trochlea	6-9	7-8	9-9	10-7
10-3	10-11	12-5	13-0	Lat. Epicondyle Hum.	8-4	9-0	10-4	10-11
10-8	11-6	13-3	13-10	Epiph. Base Metat. V.	8-6	9-3	11-0	11-9
11-2	11-11	13-7	14-3	Sesamoid Metac. I. #1	9-2	9-8	11-3	11-10
11-3	12-1	13-9	14-6	Prox. Ulna #2	9-3	10-0	11-9	12-9
11-0	11-11	13-10	14-7	Accessory Calcaneus #2	9-10	10-6	12-2	13-0
11-11	13-1	14-7	15-0	Sesamoid Metac. I. #2	10-3	10-11	12-5	12-11
13-2	13-11	15-6	16-0	Sesamoid Dist. Metac. V.	11-3	12-2	13-9	15-0
13-7	14-3	15-6	15-11	Sesamoid Thumb Interphal.	11-3	12-2	14-2	15-3

Table 6

RANGE IN TIME OF APPEARANCE OF OSSEOUS CENTERS IN THE HAND AND FOOT

(Ages given in years and months except as indicated)

BOYS				HAND		GIRLS			
Range of Middle						Range of Middle			
80 Percent						80 Percent			
50 Percent						50 Percent			
1- 8	2- 1	3- 2	3-11	Metacarpal	1	1- 1	1- 3	1-10	2- 1
1- 1	1- 3	1-11	2- 5		2	0- 9	0-11	1- 4	1- 6
1- 1	1- 5	2- 0	2- 9		3	0-10	0-11	1- 4	1- 9
1- 3	1- 7	2- 6	2-11		4	0-11	1- 1	1- 5	1-10
1- 5	1- 8	2- 9	3- 4		5	1- 1	1- 2	1- 8	1-11
1-11	2- 3	3- 5	3-11	Prox. Phalanx	1	1- 2	1- 4	1-11	2- 4
0-11	1- 1	1- 8	1-11		2	0- 7	0- 9	1- 0	1- 4
0-10	1- 1	1- 6	2- 0		3	0- 7	0- 8	1- 0	1- 3
1- 0	1- 2	1- 9	2- 0		4	0- 7	0- 9	1- 0	1- 4
1- 3	1- 6	2- 4	2-10		5	0-10	1- 0	1- 5	1- 8
1-5	1- 8	2- 7	3- 0	Midd. Phalanx	2	0-10	1- 0	1- 7	1-11
1- 3	1- 7	2- 6	2-11		3	0- 9	0-11	1- 5	1-10
1- 3	1- 7	2- 6	2-11		4	0-10	0-11	1- 6	1- 9
2- 2	2- 7	4- 3	5- 0		5	1- 2	1- 5	2- 3	2- 8

1- 0	1- 2	1-11	2- 7	Dist. Phalanx	1	0- 7	0- 9	1- 3	1- 6
2- 3	2- 8	3-10	4- 6		2	1- 3	1- 7	2- 5	2-10
1- 8	2- 0	2-10	3- 4		3	0-11	1- 2	1-10	2- 1
1- 8	2- 1	2-11	3- 5		4	1- 0	1- 2	1-10	2- 3
2- 3	2- 8	3-10	4- 7		5	1- 3	1- 7	2- 5	2-10
				FOOT					
1- 7	1-11	2-10	3- 5	Metatarsal	1	1- 2	1- 4	1-10	2- 0
2- 1	2- 5	3- 6	4- 0		2	1- 5	1- 8	2- 6	2-11
2- 6	3- 1	4- 1	4-10		3	1- 9	2- 1	2-10	3- 2
3- 2	3- 6	4-10	5- 3		4	2- 1	2- 4	3- 3	3-10
3- 5	4- 0	5- 2	5-11		5	2- 3	2- 7	3- 9	4- 5
1- 9	2- 1	2-10	3- 1	Prox. Phalanx	1	1- 1	1- 3	1-10	2- 0
1- 2	1- 4	2- 3	2- 9		2	0-10	0-11	1- 5	1- 6
1- 1	1- 3	1-11	2- 7		3	0- 7	0-10	1- 2	1- 4
1- 2	1- 4	2- 0	2- 8		4	0- 8	1-10	1- 3	1- 6
1- 9	2- 0	3- 0	3- 8		5	1- 1	1- 3	2- 2	2- 7
1- 1	1- 6	3- 0	3-10	Midd. Phalanx	2	0- 7	0- 9	1- 5	2- 0
0- 8	1- 0	2- 0	3- 7		3	0- 5	0- 7	1- 3	1-11
0-10	1- 1	2- 8	4- 9		4	0- 7	0- 9	1-11	2- 9
-	-	-	-		5	-	-	-	-
0-10	1- 1	1- 6	1-10	Dist. Phalanx	1	0- 6	0- 7	0-11	1- 2
3- 6	4- 2	5- 8	6- 3		2	2- 1	2- 5	3- 7	4- 2
3- 3	3-10	5- 1	5-11		3	2- 0	2- 3	3- 4	3-10
3- 3	3-10	5- 1	5-11		4	1- 9	2- 1	3- 0	3- 4
3- 4	4- 2	5-10	6- 9		5	1- 4	1- 9	2- 9	3- 4

Table 7

RANGE IN TIME OF FUSION OF OSSEOUS CENTERS

(Ages given in years and months except as indicated)

BOYS					GIRLS			
	Range of Middle 80 Per Cent					Range of Middle 80 Per Cent		
		50 Per Cent				50 Per Cent		
10-0	10- 5	12- 2	13-2	Talus	8- 1	8- 5	9-10	10-10
12-6	13- 3	14- 8	15-3	Base V. Metatarsal	10- 5	11- 2	12- 7	13- 6
13-2	13- 8	14-10	15-6	Trochlea	11- 1	11- 5	12- 9	13- 5
13-7	14- 3	15- 5	15-10	Lat. Epicondyle Hum.	11- 4	11-10	13- 4	13-11
14-4	-	-	-	Med. Epicondyle Hum.	12- 3	12-11	14- 4	14-10
14-4	15- 1	16- 1	-	Prox. Ulna (2 centers)	12- 2	12- 8	14- 2	14- 8
14-6	15- 2	16- 6	-	Prox. Radius	12- 3	12- 9	14- 3	14-10
14-7	15- 2	-	-	Dist. Tibia	12- 5	13- 2	14- 7	14-11
14-2	14- 8	-	-	Calcaneus (2 centers)	12-6	13- 3	14-11	15-11
-	-	-	-	Dist. Ulna	14- 9	15-5	-	-
-	-	-	-	Dist. Radius	-	-	-	-

Table 8

RANGE OF OSSEOUS DEVELOPMENT OF GIRLS BY AGE FROM BIRTH TO 14 YEARS

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
Birth	Calcaneus Talus Dist. Femur	. . . .	Prox. Tibia	Cuboid	Hd. Humerus	Capitate Hamate Coracoid(Scap.)	
3 mos.	Prox. Tibia Cuboid Hd. Humerus	. . . .	Capitate Hamate Coracoid(Scap.) 3rd Cuneiform	Capitellum Hd. Femur	Dist. Tibia	Gt.Tub.Hum.	
6 mos.	Capitate Humate Hd. Femur	Coracoid(Scap.) 3rd Cuneiform Dist. Tibia Capitellum	Ratio: Dist.Tibia 31	Gt. Tub. Hum.	Tarsus: Dist. 1	Dist. Radius Dist. Fibula Triquetrum 1st Cuneiform Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Prox. 3 4	
9 mos.	Coracoid(Scap.) Capitellum Dist. Tibia	3rd Cuneiform Gt. Tub. Hum.	Tarsus: Dist. 1	Dist. Radius Dist. Fibula Carpus: Prox. 2 3 4 Dist. 1	Triquetrum 1st Cuneiform Metacarpal: 2 Tarsus: Prox. 3 4	2nd Cuneiform Navicular (T) Carpus: Prox. 5 Mid. 3 4 Metacarpal: 3 Tarsus: Prox. 2	

(continued on next page)

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
12 mos.	3rd Cuneiform Gt. Tub. Hum.	Dist. Fibula Carpus: Prox. 3 4 Tarsus: Dist. 1	Dist. Radius Carpus: Prox. 2 Dist. 1 Tarsus: Prox. 3 4	1st Cuneiform Carpus: Prox 5 Mid. 2 3 4 Metacarpals: 2 3 Tarsus: Prox. 2	Triquetrum 2nd Cuneiform Navicular (T) Carpus: Dist. 3 4 Metacarpal: 4	Lunate Carpus: Prox 1 Mid. 5 Metacarpals: 1 5 Tarsus: Prox. 1 5	
18 mos.	Dist. Fibula Dist. Radius Carpus: Prox. 2 3 4 Dist. 1 Metacarpal: 2 Tarsus: Prox. 3 4 Dist. 1	Carpus: Prox. 5 Mid. 3 4 Metacarpals: 3 4 Tarsus: Prox 2	1st Cuneiform Carpus: Mid. 2 Dist. 3 4 Metacarpals: 1 5 Tarsus: Prox. 1	Triquetrum 2nd Cuneiform Carpus: Prox. 1 Mid. 5 Tarsus: Prox 5 Metatarsal: 1	Navicular (T) Carpus: Dist. 2 5 Metatarsal: 2	Lunate Gt. Tr. Femur Patella Prox. Fibula Tarsus: Dist. 3 4 Metatarsal: 3	
2 yrs.	Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 3 4 5 Tarsus: Prox. 1 2 Metatarsal: 1	1st Cuneiform Carpus: Prox. 1 Dist. 3 4 Metacarpals: 1 Tarsus: Prox. 5	2nd Cuneiform Navicular (T) Carpus: Mid. 5 Dist. 2 5 Metatarsal: 2	Triquetrum	Lunate Gt. Tr. Femur Patella Prox. Fibula Tarsus: Dist. 3 4 Metatarsal: 3	Med. Epi. Hum. Gt. Mult. Tarsus: Dist. 2 Metatarsal: 4	

3 yrs.	1st Cuneiform 2nd Cuneiform Carpus: Prox. 1 Mid. 5 Dist. 2 3 4 5 Metacarpal: 1 Tarsus: Prox. 5 Metatarsal: 2	Triquetrum Navicular (T) Gt. Tr. Femur Patella Tarsus: Dist. 4 Metatarsal: 3	Lunate Prox. Fibula Tarsus: Dist. 2 3 Metatarsal: 4	Metatarsal: 5	Med. Epi. Hum. Prox. Radius Gt. Mult.	Navicular (C) Less. Mult.
4 yrs.	Triquetrum Navicular (T) Gt. Tr. Femur Patella Tarsus: Dist. 3 4 Metatarsals: 3 4	Lunate Prox. Fibula Tarsus: Dist. 2 Metatarsal: 5	Med. Epi. Hum.	Prox. Radius Navicular (C) Gt. Mult. Less. Mult.	Ratio: Dist. Radius 86	Acc. Calc. 1 Dist. Ulna
5 yrs.	Lunate Prox. Fibula Tarsus: Dist. 2 Metatarsal: 5	Med. Epi. Hum. Less. Mult.	Prox. Radius Navicular (C) Gt. Mult.	Acc. Calc. 1	Dist. Ulna	Ratio: Dist. Ulna 55
6 yrs.	Med.Epi.Hum. Navicular (C) Gt. Mult. Less. Mult.	Prox. Radius Acc. Calc. 1	Dist. Ulna	Ratios: Prox.Rad. 62 Dist. Ulna 27	Ratio: Dist. Ulna 50	Trochlea Hum. Prox. Ulna 1 Pisiform

(continued on next page)

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
7 yrs.	Prox. Radius Acc. Calc. 1	Dist. Ulna Ratio: Prox.Rad. 44	Ratios: Prox.Rad.62 Dist.Ulna 37	Ratio: Dist.Ulna 61	Prox. Ulna Trochlea Hum. Pisiform	Epiph. Talus	
8 yrs.	Dist. Ulna	Ratios: Prox.Rad. 66 Dist.Ulna 51	. . . .	Prox. Ulna 1 Epiph. Talus Pisiform Trochlea Hum.	. . . .	Lat.Epi.Hum. Epiph. Base Metat. V Fusion: Talus	
9 yrs.	. . . .	Epiph. Talus Prox. Ulna 1	Pisiform Trochlea Hum.	Lat. Epi. Hum. Fusion: Talus	Epiph. Base. Metat. V	Prox. Ulna 2 Acc. Calc. 2 Sesamoid: Metac. I, 1	
10 yrs.	Prox. Ulna 1 Epiph. Talus	Pisiform Trochlea Hum. Fusion: Talus	Lat. Epi. Hum.	Epiph. Base. Metat. V Prox. Ulna 2 Sesamoid: Metac. I, 1	Acc. Calc. 2	Sesamoid: Metac. I, 2 Fusion: Base Metat. V	
11 yrs.	Pisiform Trochlea Hum. Lat. Epi. Hum. Fusion: Talus	. . . .	Epiph. Base Metat. V Sesamoid: Metac. I, 1	Prox. Ulna 2 Acc. Calc. 2 Sesamoid: Metac. 1, 2	Fusions: Base Metat. V Trochlea Hum.	Sesamoids: Metac. V Thumb Dist. Fusion: Lat.Epi.Hum.	

12 yrs.	Epiph. Base Metat. V Sesamoid: Metat. I, 1	Prox. Ulna 2	Acc. Calc. 2 Sesamoid: Metac. I, 2 Fusions: Base Metat.V	Fusion: Trochlea Hum. Lat. Epi. Hum.	Sesamoids: Metac. V Thumb Dist.	Fusions: Prox. Ulna 1 2 Prox. Radius Med.Epi.Hum. Dist. Tibia Acc. Calc. 1 2
13 yrs.	Prox. Ulna 2 Sesamoid: Metac. I, 2	Acc. Calc. 2 Fusions: Trochlea Hum Base Metat.V	Fusions: Lat.Epi.Hum. Sesamoid: Metac. V	Fusions: Prox. Ulna 1 2 Prox. Radius Med.Epi.Hum. Sesamoid: Thumb Dist.	Fusions: Dist. Tibia Acc. Calc. 1 2	. . . .
14 yrs.	Fusions: Base Metat. V Lat.Epi.Hum.	Sesamoid: Metac. V	Sesamoid: Thumb Dist. Fusions: Prox.Ulna 1 2 Prox. Radius Med.Epi.Hum.	Fusions: Acc. Calc.1 2 Dist. Tibia	. . . . .	Fusion: Dist. Ulna

A child may be expected to have all the epiphyses noted in the "Retarded" classification, up to and including her age.

Underline all the epiphyses which are present in the columns opposite her age.

For proper classification at least one-half of the centers in a particular grouping should be present.

Disregard the absence of a center in a low category when the majority of the centers are present in a higher grouping.

If there is no view of a particular center, cross it out in such a way that it does not influence the rating by appearing to be absent.

Ratio indicates the percentage relationship between the maximal transverse diameter of the epiphysis and the maximal diameter of the adjacent diaphysis.

The tibial ratios were obtained from lateral views, ratios of the radius and ulna from A.P. views.

Table 9

RANGE OF OSSEOUS DEVELOPMENT OF BOYS BY AGE FROM BIRTH TO 14 YEARS

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
Birth	Calcaneus Talus Dist. Femur	. . . .	Prox. Tibia	. . . .	Cuboid Hd. Humerus Coracoid (Scap.)	Capitate Hamate	
3 mos.	Prox. Tibia	Cuboid Hd. Humerus	. . . .	Capitate Hamate Coracoid(Scap.) 3rd Cuneiform	Capitellum Hd. Femur Dist. Tibia	. . . .	
6 mos.	Cuboid Hd. Humerus Capitate	Hamate Hd. Femur Dist. Tibia	Coracoid(Scap.) Capitellum 3rd Cuneiform	Ratio: Dist. Tibia 41	Gt. Tub. Hum.	Dist. Radius Dist. Fibula Triquetrum	
9 mos.	Hamate Hd. Femur Dist. Tibia	Coracoid(Scap.) Capitellum 3rd Cuneiform	Ratio: Dist. Tibia 46	Gt. Tub. Hum.	Dist. Radius Dist. Fibula Triquetrum	1st Cuneiform 2nd Cuneiform Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Dist. 1	
12 mos.	Coracoid(Scap.)	3rd Cuneiform Capitellum	Gt. Tub. Hum.	Dist. Radius Dist. Fibula	Triquetrum 1st Cuneiform	2nd Cuneiform Navicular (T)	

					Carpus: Prox. 2 3 4 Dist. 1 Tarsus: Dist. 1	Carpus: Mid. 3 Metacarpals: 2 3 Tarsus: Prox. 2 3 4
18 mos.	3rd Cuneiform Capitellum	Gt. Tub. Hum. Dist. Radius Dist. Fibula Carpus: Prox. 3 Tarsus: Dist. 1	Carpus: Prox. 2 4	Triquetrum 1st Cuneiform Carpus: Dist. 1 Metacarpals: 2 3 Tarsus: Prox. 2 3 4	2nd Cuneiform Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 4 5	Navicular (T) Lunate Carpus: Dist. 3 4 Metacarpal: 1 Metatarsal 1
2 yrs.	Dist. Radius Dist. Fibula Carpus: Prox. 2 3 Tarsus: Dist. 1	Gt. Tub. Hum. Carpus: Prox. 4 Dist. 1 Metacarpal: 2 Tarsus: Prox. 3	Carpus: Prox. 5 Mid. 2 3 4 Metacarpals: 3 4 Tarsus: Prox. 2 4	Triquetrum 1st Cuneiform 2nd Cuneiform Metacarpal: 5 Metatarsal: 1	Navicular (T) Lunate Carpus: Prox. 1 Dist. 3 4 Metacarpal: 1 Tarsus: Prox. 1 5	Prox. Fibula Carpus: Mid. 5 Dist. 2 5 Metatarsal: 2
3 yrs.	Gt. Tub. Hum. Carpus: Prox. 4 5 Mid. 2 3 4 Dist. 1 Metacarpals: 2 3 4 Tarsus: Prox. 2 3 4	1st Cuneiform Carpus: Dist. 3 4 Metacarpal: 5 Tarsus: Prox. 1 5 Metatarsal: 1	Triquetrum 2nd Cuneiform Navicular (T) Carpus: Prox. 1 Metacarpal: 1 Metatarsal: 2	Lunate Carpus: Mid. 5 Dist. 2 5	Gt. Tr. Femur Patella Prox. Fibula Metatarsal: 3	Tarsus: Dist. 2 3 4 Metatarsal: 4

(continued on next page)

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
4 yrs.	1st Cuneiform 2nd Cuneiform Carpus: Prox. 1 Dist. 3 4 Metacarpals: 1 5 Tarsus: Prox. 1 5 Metatarsal: 1	Triquetrum Navicular (T) Carpus: Dist 2 5 Metatarsal: 2	Lunate Gt. Tr. Femur Prox. Fibula Carpus: Mid 5 Metatarsals: 3 4	Patella Tarsus: Dist. 3 4 Metatarsal: 5	Prox. Radius Tarsus: Dist. 2	Med. Epi. Hum. Navicular (C) Gt. Mult. Less. Mult.	
5 yrs.	Triquetrum Navicular (T) Gt. Tr. Femur Carpus: Dist. 2 5 Metatarsals: 2 3	Patella Prox. Fibula Carpus: Mid. 5 Metatarsal: 4	Lunate Tarsus: Dist. 2 3 4 Metatarsal: 5	Prox. Radius Less. Mult.	Med. Epi. Hum. Navicular (C) Gt. Mult.	Ratio: Prox. Rad. 54	
6 yrs.	Lunate Patella Prox. Fibula Carpus: Mid. 5 Tarsus: Dist. 3 4 Metatarsals: 4 5	Tarsus: Dist. 2	Prox. Radius	Med. Epi. Hum. Navicular (C) Gt. Mult. Less. Mult.	Dist. Ulna Ratio: Prox. Rad. 62	Acc. Calc. 1	

7 yrs.	Tarsus: Dist. 2	Prox. Radius Navicular (C)	Med. Epi. Hum. Gt. Mult. Less. Mult.	Dist. Ulna Ratio: Prox. Rad. 55	Acc. Calc. 1 Ratio: Prox. Rad. 71	Prox. Ulna 1	——
8 yrs.	Prox. Radius Navicular (C)	Med. Epi. Hum. Gt. Mult. Less. Mult.	Dist. Ulna Acc. Calc. 1 Ratio: Dist. Ulna 31	Ratios: Prox. Rad. 73 Dist. Ulna 57	Ratio: Dist. Ulna 76	Epiph. Talus Trochlea Hum. Prox. Ulna (1) Pisiform	——
9 yrs.	Med. Epi. Hum. Gt. Mult. Less. Mult. Dist. Ulna	Acc. Calc. 1 Ratio: Dist. Ulna 36	Ratios: Dist. Ulna 61 Prox. Rad. 73	Trochlea Hum. Ratio: Dist. Ulna 76	Epiph. Talus Prox. Ulna (1) Pisiform	. . . .	——
10 yrs.	Acc. Calc. 1	Ratios: Prox. Rad. 77 Dist. Ulna 52	Trochlea Hum.	Epiph. Talus Prox. Ulna (1)	Pisiform Fusion: Talus	Lat. Epi. Hum. Acc. Calc. 2 Sesamoid: Metac. I, (1) Epiph. Base Metat. V	——
11 yrs.	Epiph. Talus	Trochlea Hum. Prox. Ulna (1)	. . . .	Pisiform Lat. Epi. Hum. Fusion: Talus	Acc. Calc. 2 Epiph. Base Metat. V	Prox. Ulna (2) Sesamoid: Metac. I, (1)	——
12 yrs.	Trochlea Hum. Prox. Ulna (1)	Pisiform	Lat. Epi. Hum. Fusion: Talus	Epiph. Base Metat. V Sesamoid: Metac. I, (1) Acc. Calc. 2	Prox. Ulna (2) Sesamoid: Metac. I, (2)	Fusion: Base Metat. V	——

(continued on next page)

Age	Retarded	Below Average	Low Average	High Average	Above Average	Accelerated	Rating
13 yrs.	Pisiform Lat. Epi. Hum.	Fusion: Talus	Epiph. Base Metat. V Sesamoid: Metac. I, (1) Acc. Calc. 2 Prox. Ulna 2	. . . .	Sesamoid: Metac. I, (2) Fusion: Base Metat. V	Sesamoids: Metac. V Thumb Dist. Fusions: Trochlea Hum. Lat. Epi. Hum.	
14 yrs.	Epiph. Base Metat. V Fusion: Talus	Sesamoid: Metac. I, (1) Acc. Calc. 2 Prox. Ulna (2)	Sesamoid: Metac. I (2)	Fusions: Base Metat. V Trochlea Hum. Sesamoid: Metac. V	Sesamoid: Thumb Dist. Fusion: Lat. Epi. Hum.	Fusions: Acc. Calc. 1,2 Dist. Tibia Prox. Ulna 1,2 Prox. Radius Med. Epi. Hum	

A child may be expected to have all the epiphyses noted in the "Retarded" classification, up to and including his age.

Underline all the epiphyses which are present in the columns opposite his age.

For proper classification at least one-half of the centers in a particular grouping should be present.

Disregard the absence of a center in a low category when the majority of the centers are present in a higher grouping.

If there is no view of a particular center, cross it out in such a way that it does not influence the rating by appearing to be absent.

Ratio indicates the percentage relationship between the maximal transverse diameter of the epiphysis and the maximal diameter of the adjacent diaphysis.

The tibial ratios were obtained from lateral views, ratios of the radius and ulna from A.P. views.

Table 10

PER CENT OF CHILDREN WITH SIMILAR RATINGS FROM ONE AGE PERIOD TO ANOTHER

	Birth	2 yrs.	4 yrs.	6 yrs.	8 yrs.	10 yrs.	12 yrs.	14 yrs.
Birth	. .	76	75	70	67	55	44	63
2 yrs.	. .	. .	94	86	77	77	75	65
4 yrs.	. .	. .	. .	85	77	75	75	67
6 yrs.	. .	. .	. .	. .	90	80	78	58
8 yrs.	. .	. .	. .	. .	. .	88	81	67
10 yrs.	. .	. .	. .	. .	. .	. .	91	65
12 yrs.	. .	. .	. .	. .	. .	. .	. .	56
14 yrs.	. .	. .	. .	. .	. .	. .	. .	. .

Summary

1. Approximately 50,000 X-ray films of 323 children from birth to 14 years were studied.

2. The percentages of boys and girls having a certain osseous center at various ages are given.

3. The range of appearance of the osseous centers is given for both the middle 50 per cent and the middle 80 per cent of both boys and girls.

4. A simple method of estimating osseous development is offered. This method is particularly useful if the same child is to be examined repeatedly.

5. It was found that children tend to maintain a fairly constant rate of osseous development over long periods of time.

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ORGANISMIC INTERPRETATION OF INFANT VOCALIZATIONS

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INTRODUCTION

The present paper is an attempt to integrate certain facts of linguistic development in infants with the laws of developmental direction and with the organismic hypothesis which have been proposed chiefly in the areas of anatomical and gross motor development, as well as to relate them to recent theories in comparative linguistics. Jakobson (18), the linguist, claims that in all languages the time sequence in the acquisition of sound elements is the same. If this is true, must there not be then, some basic developmental changes common to children of all nationalities, to account for such findings?

Students of child development are familiar with the intimate interrelationships existing between structure and function, but in the complexities of the earliest stages in the acquisition of speech, certain important and striking concomitants are likely to be overlooked. Language, which is the most unique and highest form of behavior, is characteristic of man alone, it involves some of the most intricate parts of his neuro-muscular system, as well as the finest degrees of motor coordination of which he is capable.

The organs involved in speech do not serve speech alone, but are first used for two much more vital functions essential to the survival of the organism: namely, breathing and eating. If the organism is to survive, the first thing for which these organs must be used is an abrupt and complex physiological adjustment from the fetal to the post-natal type of circulation which involves the onset of respiriation. For the first few weeks the infant's breathing is rapid, irregular, and abdominal in type (21). It generally becomes deeper, more regular, and rhythmical; the thorax is used more and eventually the process becomes quite automatic. In Irwin's (15, 16) detailed phonemic investigations of the sounds uttered by young infants, 50 per cent of all sounds uttered by the newborn and 97 per cent of all consonants heard at this early age were the aspirate *h* sound which is undoubtedly associated with the child's gasping for breath in the state of oxygen hunger described by Ribble (24). Interestingly enough, the letter *h* is derived from the Greek word which means "rough breathing."

In the newborn period there are few non-crying sounds heard (13, 14), and, as Ribble (24) states, most of the early crying is, in effect, "emergency respiration." Some writers have brought out, too, that the early non-crying

or cooing sounds heard in the second month of life are an indication that respiration is well established, and that the child has breath to spare for other than emergency uses.

The second important physiological function involving the speech organs is the establishment of feeding habits. The child must learn to suck and to ingest feed if he is to satisfy his food hunger and to survive. Much of the neonate's waking time is therefore devoted to the establishment of skill in sucking and swallowing, and in this period the tongue and lips are primarily highly sensitive organs of touch which enable the child to feel and secure the source of food. It is to be noted that practically no non-crying utterances are heard until after the two vital processes of breathing and feeding are well established (13). Only after these functions essential to the survival of the organism are established does the beginning of their third function of speech emerge. Of considerable importance in this connection is Shohara's (28) claim that all movements involved in speech are first used for, and are virtually identical with movements of swallowing, chewing, and other masticatory movements.

In the neo-natal period there is little neuro-muscular control of posture and the child remains in the supine position much of the time. Most writers who have studied the child's oral cavity, many by means of X-ray techniques, are agreed that there is usually a slight space anteriorly between the gum pads in the newborn infant, although the lips are characteristically occluded (2, 6, 7, 8, 21, 29). Usually there are no teeth. The oral cavity is small, having a short anterior to posterior measurement. The palate, which is very sensitive to tactile stimulation, is flat and lacks the characteristic arch found in older persons. The tongue is relatively large and practically fills the oral cavity, even protruding much of the time. The sucking pads in the cheek which are characteristic of infancy are very prominent and enable the infant to suck and to breathe at the same time (5, 25).

Vocalization and the Law of Developmental Direction

The utterance of the various vowel sounds depends on the shape of the oral cavity which modifies the stream of air being expelled from the lungs and passing over the vocal cords. Chen and Irwin's (9) phonemic analysis of infant speech indicates that vowel types predominate in the child's early utterances until the end of the first year of life when the first true words usually are spoken. From that age on, consonants appear in greater variety than do the vowels. In their frequency analysis, Irwin and Chen (13) find that vowels occur five times more frequently than consonants in the first bi-monthly age group, and in spite of the fact that the *h* sound, which they classify as a consonant, constituted 50 per cent of all the sounds heard at that time. It is evident, then, that practically all the early utterances are of a vowel character. When the vowels of Irwin's (13) data were analyzed for place of phonation, front vowels were found to appear first and to con-

stitute 72 per cent of the vowels at two months of age. Back vowels, or those formed with the back part of the oral cavity, appear later, accounting for only 2.3 per cent of the vowel sounds at first. Irwin (13) concludes that there appears to be a regular developmental progression of vowels from front to back of the oral cavity. Variations from one vowel sound to another involve the comparatively gross movements made by the dorsum or root of the tongue, which embryologically has different origins from the blade and tip of the tongue. The root of the tongue derives its motor innervation from the 12th cranial nerve, or the hypoglossal coming from the medulla, whereas the motor innervation of the blade of the tongue comes from the mandibular division of the trigeminal nerve in the region of the pons (1, 22). The blade or oral part of the tongue is the part involved in the finer movements of consonant production, which develop considerably later than the vowels.

It appears, then, that in the field of linguistic development there is some evidence that gross motor development precedes finer motor coordination in the speech musculature. Just as in motor development the gross muscles of shoulder and arm begin to function before finger dexterity is acquired, so the grosser tongue movements involved in vowel production precede the finer adjustments required for the production of consonant sounds. Vowel sounds may, therefore, be thought of as the raw material of language, somewhat analogous to the mass activity of the infant in the motor realm, and consonants may be considered to involve the specific movements which become individuated in order to produce true speech.

When consonant development is studied (15) it appears that development proceeds from the back to the front of the oral cavity, the child first making a preponderance of glottal and velar sounds, and later making the sounds involving the use of the anterior parts of the oral cavity: namely, the teeth, the tip of the tongue, and the lips. In the beginning there are very few kinds of consonants heard, but of those uttered, 97 per cent are reported to be glottal and velar sounds or back consonants, which it has been indicated are predominantely *h* sounds associated with breathing, and the others are the *g* and *k* and the glottic stop which sounds are primarily associated with the feeding situation. These early consonants, therefore, seem to be those which are associated with the pre-speech uses of these organs.

Vocalization and Postural Control

Certain changes in linguistic development seem to be related to important phenomena in the child's motor development, especially to the various stages in the assumption of the erect posture. The reports in the literature of babies' cooing and vocalizing in response to social stimulation about the second to the third month occur just after the child has learned to hold his head erect (20). The babbling period his its onset at about seven months

of age just after the child has mastered the skill of sitting alone (26). The appearance of the first words about the end of the first year coincides approximately with the age of standing alone (26 and 31). When the child walks alone at the average age of approximately 15 months, his breathing becomes more thoracic. His growing independence at this stage is also revealed in the realm of language, for it is at this same period that he begins to enlarge his vocabulary and to combine two and three words into rudimentary sentences.

If Irwin's (15) growth curve for the percentage of nasal sounds is examined, it appears that there were no nasal sounds noted in the first four months. During this period, however, the child remains in the supine position most of the time. There is a gradual rise, however, in the percentage of nasal sounds as the child is propped up more of the time. The nasal sounds then constitute about 10 per cent of the child's consonant sounds from the age of sitting alone until the age of walking alone. This is a period when the child is concentrating most of his powers on learning new motor skills, and as Shirley (27), Bean (3), and others have noted there is a cyclical relationship between the acquisition of motor and verbal skills. As soon as walking is well established there is another marked increase in the percentage of nasal sounds, which is also associated with increased thoracic breathing and with the assumption of the erect posture.

When the child lies down in the characteristic position of infancy, the uvula and soft palate are pulled downward by the force of gravity, so that the nasal passage, which is very small in the infant, is virtually blocked off by these soft tissues, making the pronunciation of nasal sounds impossible. The assumption of the erect posture changes the pull of gravity on these soft tissues by approximately 90 degrees. The uvula and velum then hang down into the pharynx in the adult position so that the nasal passage is open, and the expulsion of air through it in the pronunciation of nasal sounds becomes possible. An X-ray study by Holbrook and Carmody (11) showed that even a 20 degree shift in head tilt changed the pronunciation of vowels by adults, but the writer has found no investigation on infants dealing specifically with the problem of postural position in infant vocalization. It is only reasonable to argue, however, that if a 20 degree shift in adult head tilt affects articulation, that a 90 degree shift in the infant's head position would be reflected in his speech sounds.

Vocalization in Relation to Feeding Behavior

The high percentage of plosive sounds in Irwin's (15) data is due to his inclusion in this category of the velar sounds *g* and *k* which are associated with the early stages of the feeding situation. The apparent drop in fricatives is due to the inclusion of the most frequent early sound, the aspirate *h* as a fricative (15). Some phoneticians classify this sound separately and treat it as neither a vowel nor a consonant. If that phoneme were omitted

as a speech sound in Irwin's analyses, and were treated merely as gasping or exaggerated breathing, this irregularity of the fricative curve would be markedly reduced, the other phonemes of the fricative group, *f*, *v*, ð, θ, *s*, ʃ, ʒ, and *z* all appear after the front teeth have erupted and then show increases with age.

Later developments in feeding behavior are outlined in detail by Gesell and Ilg (10). The relationship of developments in feeding behavior to language development, while less clear-cut than those to breathing and the assumption of the erect posture, are of considerable interest also. When the sucking drive is very strong, especially in the third and fourth months, there is little progress in vocalization, but the naso-pharyngeal cavity is enlarging rapidly with the exercise involved in nursing. In fact, the nasal cavity doubles its height in the first year of life. The babbling stage sets in at about seven months. This, it should be noted, is not only the age at which the average child sits up, but is also the customary age for the introduction of spoon and cup feeding. At this time also the sucking drive begins to wane, and from this time on most children are given increasing experience with solid food. Sprawson (32) and others have pointed out the importance of adequate nursing experience, preferably breast feeding, for the development of the hard palate and proper spacing of the teeth. As the oral cavity enlarges through the exercise of nursing, the tongue is no longer protruded. During the sedentary period, sucking wanes, there is an increasing preference for solid food, and the valvular function of the sucking pads is no longer needed (5).

Gesell and Ilg (10) report that most solid foods are taken well by children ten months of age, and this is the same age at which most writers have reported syllabic utterances used in anticipation of the feeding situation (20, p. 483). Are these not really the child's first words in the sense that they are used consistently in a specific situation? For it is indeed in such circumstances that vocal sounds take on meaning. By one year of age, most babies are being weaned from the bottle, and are doing considerable finger-feeding of crackers, zwieback, and the like, so that chewing and biting movements involving additional exercise of the mandible appear. Immediately following this period, when the average child has a spoken vocabulary of about three words (31), it is interesting to note the practical concomitants of such activities indicative of increasing independence of self-feeding, walking, and the rapid increase in vocabulary and the combining of words to express his broadening experience in the second year of life.

Vocalization and Dentition

When consonant sounds are studied according to place of articulation, there appears a marked increase in post-dental, labial, and labio-dental sounds, or the front consonants made with the teeth and lips during the 6th to the 28th month (15). These sounds occur at just the age period in

which most children acquire their deciduous teeth. It is not surprising, therefore, that there is a paucity of front consonants in the early months, before the baby has either central or lateral incisors to form a front wall for his oral cavity. Between six and eight months of age these front teeth usually appear (34), and from that age on Irwin's (15) data reveal a marked increase in the percentage of front consonants. A plateau is reached in the curve for labials and labio-dentals as the child's dentition proceeds posteriorly to the canines and second molars, which enable him to establish a definite occlusion and to handle solid food more adequately in chewing and masticatory movements, but the post-dental sounds continue a steady increase through the period of dentition.

Conclusion

It thus appears that the detailed analysis of the child's prelinguistic utterances in terms of groups of phonemes has yielded marked developmental trends. Vowel development seems to be analogous to the gross motor development and consonant development to the individuation of specific finer movements essential for the pronunciation of real words. While at first it may seem contradictory that one aspect of linguistic development, namely vowel development, proceeds from front to back of the oral cavity, and consonant development from back to front, these facts can be harmonized with the other known laws of child development if the embryological development of the tongue, which is the primary organ of speech, is considered. The tongue is formed by the joining of three parts; the dorsum or root develops from the fetal copula and is primarily concerned with swallowing movements. This is the part which, together with the muscle of the tongue, is involved in vowel production. Vowel development progresses from front to back, and hence follows the law of developmental direction, for it proceeds in the cephalo-caudal direction. It might also be pointed out that the fusion of the palatal processes with each other and with the nasal septum in the formation and ossification of the face and hard palate also progresses from front to back (1). The oral part of the tongue or the blade, however, the fine control of which is essential to the production of consonant sounds needed to form the individual character of the various syllables, develops from the fusion of the two lateral lingual swellings and is innervated by the higher nerve centers (1, 22). Thus, consonant development, which appears to be more significant for later language development, seems to follow the law of proximo-distal development, proceeding from the mid-line toward the periphery. It is thought, therefore, that the emergence of a variety of consonant sounds with the necessary fine degree of control of tongue-tip and lips marks the beginning of cortical control of the speech function.

If these hypotheses and interpretations are confirmed by future investigations, especially by longitudinal studies, it appears that the heretofore mysterious prelinguistic utterances of infancy can probably be harmonized

with known facts about other aspects of the child's development; that when studied in cross-sectional perspective, infant speech shows remarkable correspondence with other aspects of development. In the normal course of events the average child does not use real language until after he has established satisfactory respiration, acquired front teeth, had some experience with solid food, and assumed the erect posture. Such a common developmental core could readily account for Jakobson's (18) observations of uniformity in the order of appearance of phonemes from one language to another. These interpretations of widely scattered bits of information are but further evidence of the complexity, the unity, and the harmony in the growth of the whole child.

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SOME DATA ON THE VALIDITY OF THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN [1]

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The problem investigated in this study is the validity of the Wechsler Intelligence Scale for Children (WISC) at the five- and six-year levels. The Revised Stanford-Binet, Form L, is used as the criterion. A number of similar studies have appeared since the initiation of the present project. The most thorough of these was conducted by Krugman *et al.* (4). Results from several others are summarized by Pastovic and Guthrie (6).

SUBJECTS AND PROCEDURE

The subjects were 50 five-year-olds and 50 six-year-olds, of whom 72 were resident in children's homes while all but one of the rest attended kindergarten or first grade in parochial schools. Each child had the same examiner for both tests. Counter-balanced order was followed, but through an oversight there were 52 in one group (Stanford-Binet first) and 48 in the other (WISC first). Many of the children were given the two tests in the same day; the maximum interval was seven weeks.

RESULTS

Since the procedures used are familiar enough, our results may be presented in a series of tables with a minimum of comment. Tables 1 and 2 contain the correlations and means for the Binet and the three major indices of WISC performance. Table 3 shows the median IQ and the range for each of the tests at five and at six years. In Table 4 we have (*a*) the cumulative frequencies of ocurrence for various discrepancies between Binet and WISC Full Scale IQs, and (*b*) the probabilities, in terms of chances in 100, of obtaining similar discrepancies in other groups if the distribution in this group be taken as representative. Table 5 gives the same for the Binet and the WISC Performance Scale IQs, which did not show such great discrepancies at the six-year level. Correlations and means for the various sub-

[1] The data have been taken from Master's Theses written by the first two authors and checked, selected, and reinterpreted by the third author. Thanks are due the following institutions for their cooperation: St. Francis Home for Orphan Boys, Detroit; Gesu School, Detroit; Holy Name School, Birmingham, Michigan.

tests are presented in Tables 6 and 7. The correlations may be compared with those given by Wechsler (9, p. 10), although the criterion variables he used were the various WISC IQs.

TABLE 1

CORRELATIONS OF THE WECHSLER INTELLIGENCE SCALE FOR CHILDREN AND THE STANFORD-BINET, FORM L*

	Five-Year-Olds	*Six-Year-Olds*	*Both Together*
Stanford-Binet and:			
WISC Verbal Scale	.790	.711	.753
WISC Performance Scale ...	.727	.715	.715
WISC Full Scale	.844	.785	.807

* The correlations are *r*'s; all are significant beyond the 1 per cent level.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF STANFORD-BINET AND WISC IQ'S FOR TWO AGE GROUPS

	Stanford-Binet		WISC Full		WISC Verbal		WISC Performance	
Group	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Five years ..	102.90	15.54	91.70	13.28	89.90	12.62	94.80	13.54
Six years ...	107.40	13.05	101.80	12.40	98.30	12.50	105.90	12.70
Total	105.15	14.54	96.75	13.81	94.10	13.23	100.35	14.25

Differences between the WISC and Stanford-Binet Means are significant at the .001 level of confidence, except for that comprising the Performance Scale for the six-year-old group, which difference is at the $p = .280$ level of confidence.

TABLE 3

MEDIAN AND RANGE FOR STANFORD-BINET AND WISC IQ'S FOR TWO AGE GROUPS

	Stanford-Binet		WISC Full		WISC Verbal		WISC Performance	
Group	*Median*	*Range*	*Median*	*Range*	*Median*	*Range*	*Median*	*Range*
Five years ..	103.8	58-140	91.5	66-125	89.5	65-121	95.2	68-124
Six years ...	104.1	89-142	99.5	77-132	97.8	72-120	104.5	85-140
Total	104.0	58-142	96.5	66-132	93.3	65-121	101.0	68-140

TABLE 4

CUMULATIVE FREQUENCIES AND PROBABILITIES OF VARIOUS INDIVIDUAL DISCREPANCIES BETWEEN THE WISC FULL SCALE IQ'S AND THE STANFORD-BINET IQ'S

*Discrepancy**	Frequencies		Chances in 100	
	Five-Year-Olds	*Six-Year-Olds*	*Five-Year-Olds*	*Six-Year-Olds*
25 or more	1	1	2	2
20 or more	7	3	14	6
15 or more	20	6	40	12
10 or more	32	13	64	26
5 or more	41	25	82	50
1 or more†	44	36	88	72
0	..	..	..	..
— 1 or more	6	14	12	28
— 5 or more	2	6	4	12
—10 or more	..	1	..	2

* A discrepancy is considered positive if the WISC is lower than the Stanford-Binet; negative, if the WISC is higher.

† This and the following two intervals have been changed so as to facilitate combining the positive and negative frequencies if one wishes to do so.

TABLE 5

CUMULATIVE FREQUENCIES AND PROBABILITIES OF VARIOUS INDIVIDUAL DISCREPANCIES BETWEEN THE WISC PERFORMANCE SCALE IQ'S AND THE STANFORD-BINET IQ'S

*Discrepancy**	Frequencies		Chances in 100	
	Five-Year-Olds	*Six-Year-Olds*	*Five-Year-Olds*	*Six-Year-Olds*
30 or more	1	..	2	..
25 or more	4	..	8	..
20 or more	9	2	18	4
15 or more	13	4	26	8
10 or more	21	10	42	20
5 or more	34	18	68	36
1 or more†	39	23	78	46
0	2	2	4	4
— 1 or more	9	25	18	50
— 5 or more	6	12	12	24
—10 or more	2	6	4	12
—15 or more	..	2	..	4

* Discrepancies and cumulations as in Table 4.

† Intervals changed as in Table 4.

TABLE 6

CORRELATIONS OF THE WISC SUBTESTS WITH THE STANFORD-BINET

Subtests	Five-Year-Olds		Six-Year-Olds		Both Together	
	r	*Sign.**	*r*	*Sign.**	*r*	*Sign.**
Information	.533	1%	.516	1%	.534	1%
Comprehension	.562	1%	.360	2%	.489	1%
Arithmetic	.697	1%	.456	1%	.596	1%
Similarities	.465	1%	.546	1%	.512	1%
Vocabulary	.416	1%	.653	1%	.515	1%
Digit Span	.520	1%	.522	1%	.524	1%
Picture Completion	.626	1%	.445	1%	.565	1%
Picture Arrangement	.180	>20%	.609	1%	.395	1%
Block Design	.649	1%	.547	1%	.609	1%
Object Assembly	.494	1%	.326	5%	.457	1%
Coding	.652	1%	.125	>20%	.388	1%
Mazes	.520	1%	.590	1%	.565	1%

* Significance level was obtained from the usual tables. *N* was 50 for each age group and 100 for the whole group, except in the following cases: with five-year-olds: Digits, 43; Coding, 48; Mazes, 31; with six-year-olds: Vocabulary, 49; Digits, 44; Mazes, 32; for both together: Vocabulary, 99; Digits, 87; Coding, 98; Mazes, 63.

TABLE 7

MEANS AND STANDARD DEVIATIONS ON THE WISC SUBTESTS

*Subtests**	Five-Year-Olds		Six-Year-Olds		Both Together	
	Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
Information	7.86	2.55	9.12	2.86	8.49	2.78
Comprehension	8.88	3.33	9.72	2.81	9.30	3.11
Arithmetic	8.84	2.68	10.74	2.67	9.79	2.84
Similarities	8.34	2.96	9.58	3.42	8.96	3.26
Vocabulary	8.16	3.13	8.57	2.62	8.36	2.90
Digit Span	8.42	2.91	10.36	2.93	9.40	3.08
Picture Completion	9.42	3.22	11.24	2.74	10.33	3.12
Picture Arrangement	10.04	2.06	10.14	2.76	10.09	2.43
Block Design	9.00	3.10	11.60	2.74	10.30	3.20
Object Assembly	9.14	3.07	11.28	3.54	10.21	3.48
Coding	8.54	2.52	10.26	3.19	9.42	3.01
Mazes	9.29	2.67	10.50	1.94	9.91	2.40

* *N*'s were the same as for Table 5. Means and standard deviations are in weighted score units.

Practice-effect from one test to the other is often a problem to the clinician. Combining the data for both age groups, we find Stanford-Binet means of 104.94 for Group I (Stanford-Binet first) and 104.98 for Group II (WISC first). The WISC Full Scale means are 97.33 for Group I and 96.04 for Group II. There appears to be no practice-effect.

Discussion and Conclusions

The correlations of the WISC IQs with the Stanford-Binet range from .711 to .844 and are quite similar to those obtained in other studies. The "order of merit" is: Full Scale, Verbal Scale, Performance Scale; although there is little difference between the last two. Considering these data and those reported in other studies (6), one can hardly doubt that the WISC is in general measuring the same thing as the Stanford-Binet. At least with these age groups, the Performance Scale does not seem to be measuring a distinct aspect of intelligence, since the correlations with the Binet are high and quite similar to those for the Verbal Scale.

The group means indicate that all the WISC IQs underrate the five-year-old by 8 to 13 points, and that the Full and Verbal Scale IQs underrate the six-year-old by 5 to 9 points. Strangely, it is the Performance Scale that yields a mean for six-year-olds which is for all practical purposes the same as that for the Binet. The finding of lower means is in agreement with the data of Krugman *et al.* (4). The satisfactory results with the Performance Scale at the six-year level are somewhat obscured by the contrary fact that two of the subtests, Object Assembly and Coding, showed poor correlations with the Binet (cf. Table 6).

From Table 4, which has to do with the individual discrepancies between the Binet and the WISC Full Scale, we must conclude that there are almost 9 chances in 10 that a child of five years will score lower on the WISC, and 3 chances in 5 that he will score at least ten points lower. This is quite serious in clinical work. On the Performance Scale (Table 5) the situation is about the same.

A six-year-old child has roughly seven chances in ten of scoring lower on the WISC Full Scale and almost three chances in ten of scoring ten points lower. However, on the Performance Scale he has an even chance of obtaining an IQ higher than that on the Binet. The Performance Scale IQ would appear to be fairly reliable at this age; although there is still one chance in five of an IQ lower by ten or more points.

The subtest correlations (Table 6) are generally quite good as such figures usually go. However, using the Stanford-Binet performance as a criterion, the following subtests appear to be of slight validity according to our data: Picture Arrangement with five-year-olds and Coding with six-year-olds. The validity of Object Assembly at age six seems also to be doubtful. The subtest means (Table 7) indicate that all but Picture Arrangement,

a test apparently of little validity, yield scores for five-year-olds roughly one or two points below the expected weighted score mean of 10 (Binet mean: 102.90). At six years all the performance and two of the verbal subtests, Arithmetic and Digit Span, appear to be about correct; the remainder of the verbal subtests are some one or two points too low (Binet mean: 107.40).

For the present, caution is suggested in the use of the WISC at ages five and six. The Performance Scale seems reliable enough at six years, but Coding should, perhaps, be omitted, and also Object Assembly. The general evidence of the validity of the WISC and the special merits of this type of intelligence test indicate that revision of the norms and some of the test items would be a good investment.

Summary

The WISC and the Stanford-Binet, Form L, were administered to 50 five-year-old and 50 six-year-old children in counterbalanced order. The correlations indicate that the major scales of the WISC are valid for these age groups if we assume that the Binet performance is a criterion of intelligence. However, there is a definite tendency to lower scores on the WISC, if we except the Performance Scale with children of six. In individual cases, great discrepancies occur between IQs on the two tests.

The WISC subtests are generally valid. However, Picture Arrangement is unsatisfactory with children of five years; Coding with children of six years; Object Assembly is questionable with the latter group. Five-year-olds are underrated by all tests except Picture Arrangement (which correlates poorly with the Binet); six-year-olds, by four of the verbal tests: Information, Comprehension, Similarities, and Vocabulary.

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THE CONSTANCY OF THE AREA FACTOR IN THE TALKING, WALKING, AND DRAWING OF NORMAL CHILDREN[1]

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INTRODUCTION

It has been assumed that the tendency for an individual to fill a certain amount of space when making postural, manual, or gestural responses is relatively constant. That is to say, some individuals habitually need less space for their expressive movements, while other persons characteristically fill more space with their movements. This individualistic use of space is called the area factor.

To Gardner Murphy ". . . the degree of 'space-filling' tendency (the area factor) is a generalized expression of the individual that varies sharply from one man to another" (6, p. 624). He goes on to say that there is something "in the markedly space-filling individual that causes him to spread out more than his fellow does when he makes an expressive movement" (6, p. 624). He explains these differences in the area factor by their dependence upon the global attitudes of the individual. Consequently, it is to be expected that the parts bear a relationship to one another as they all spring from the same global matrix. They all exist as aspects of the same organism and are all stimulated by many similar inner and outer factors. For example, "whatever involves *outgoing* response appears in all specific facets of behavior" (6, p. 598). The greater the area factor in one situation, the greater we can expect it to be in other situations.

Allport and Vernon in their classical investigation of expressive movement remarked, "It is a matter of common belief that the gestures or expressive movements of a person are consistent with one another" (1, p. 173). Yet, they noted that little was actually known concerning the reliability of expressive acts or the constancy of the area factor.

Evidence for the constancy of the area factor has been found. Allport and Vernon (1) noted quantitative relations existing in the area factor of many different acts. They found an outgoing person made big gestures, wrote in

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a large script, drew large pictures, and made long strokes for his check marks in rating himself. A contractile person held his hands close together, wrote in a small script, drew small pictures, and made short check marks. They noticed that "The average correlations for tasks performed with different groups of muscles are just about as high as those performed with identical muscles" (1, p. 176).

A study made a few years later (2) lent confirmation to the area factor. It was found that non-dominant subjects used significantly less space and made fewer comments than dominant subjects.

"The same approach to the area factor has been used by those who have worked with children's drawings; they have repeatedly found that sweeping strokes or the massing of color over a large area is characteristic of self-assurance, whereas the shy child confines himself to one corner of the paper . . ." (6, p. 625).

Two early studies also indicated a relationship in the area factor of space covered in walking and "word space," i.e., number of words spoken. Marston (5) recorded the space introverted and extroverted children covered in a museum hall by drawing a line on tracing paper over a plot of the territory. He found introverted subjects covered far less area than extroverted subjects. Madorah Smith (7) found the introverted children averaged approximately 400 words an hour less than the extroverted subjects in one hour of group play.

There would seem to be, then, reason to expect constancy of the area factor in the speaking, walking, and drawing of normal children. Those who speak the greater number of words could be expected to walk over the most territory and draw the largest pictures and vice versa.

Problem, Purpose, and Methodology

The problem has been an attempt to determine the constancy of the area factor in the speaking (number of words), walking (area covered), and drawing (volume of human figure drawing) of normal children. On the basis of the literature cited it was hypothesized that children who talked most would cover the most area and draw the largest human figures.

Subjects. Twenty children, ten of each sex were selected, after careful screening, as being chronologically, socially, and intellectually satisfactory for the purposes of this study. To be chronologically suitable a child could not vary more than four months from the age of four, six, eight, ten, or twelve years. There were four children in each of these age groups. Social adjustment was determined by teacher interviews and by examination of cumulative record material. In order to be considered intellectually satisfactory, a child's Stanford-Binet IQ score could not differ from the normal score of 100 by more than one sigma.

These requirements were more rigorous than any encountered in previous experiments touching upon the concept of the area factor. They were

established to circumvent the possible influence of serious behavior problems and extremely high and low intelligence on the use of space, or amount of talking, walking, and drawing.

Methodology. After being screened and found suitable for experimental purposes each child was given three one-hour, individual nondirective play sessions. Three was selected as the most desirable number of sessions for the following reasons:

(1) The child would have had an opportunity to become familiar with the play room. His time would not be spent in exploring the room.

(2) The child would have selected his favorite play activities, if such a selection were going to be made, and would be behaving in a characteristic manner.

(3) The experimenter would no longer be a stranger to the child.

(4) The child would have discovered the freedom of the room and would not play in a constricted manner if he did not wish to.

(5) The meetings would not have become tiresome to the child.

Half the children were asked to draw the picture of a person before each play session and half were asked to make the drawing immediately following each play session. The following week those who had made their drawings before play were required to draw after play and vice versa.

Verbatim style records were kept of the child's conversation during each of the meetings in the play room.

A diagram tracing the child's course on a scale drawing of the play room was made from the verbatim style records immediately after each session.

Results

The question of the constancy of the area factor in speaking, walking, and drawing was determined by an overall measure of concordance of the significance and extent in similarity of space use among the twenty subjects. This measure was obtained by using the W statistic of Kendall and Smith (4). The W statistic makes no assumption concerning the data other than that ranking is possible. No hypothesis that there is some underlying frequency distribution to which the rankings correspond need be made. For the analysis of area constancy in the present study, the coefficient of concordance was .34, which indicated a significantly low degree of similarity in the rank order of space use in the three categories. This finding showed that each of the subjects was filling space in a widely unreliable manner, in walking, talking, and drawing. It meant that there was almost no constancy of the area factor.

The children had been carefully selected on the basis of age. Because there were four children in each of the four-, six-, eight-, ten-, and twelve-year-old groups, statistical treatment of the relationships between age and area factor was unwarranted. However, by inspection of the data no relationship between age and area factor was discerned.

Discussion

According to the present finding, children intellectually and socially normal, ranging in age from 4 to 12 years, have no constancy in the area factor of walking, talking, and drawing. This finding does not agree with an expected result based upon the concept of area factor found in the literature.

A reconsideration of the literature seems necessary. Gardner Murphy (6), an outstanding supporter of the constancy of area factor, drew most of his material from Allport and Vernon (1). They conducted over 30 different tests with a diversified group of 25 males. The subjects ranged in age from 18 to 50 years and were students or business and professional men. They found no evidence for a general factor saturating all the measures. Rather, they isolated three factors, "an *areal* (or expansive) factor, a *centrifugal* factor, and a factor of *emphasis* in movement" (1, p. 778). Such categories, discovered in an analysis of data obtained from an entire group, led them to assume ". . . that insofar as personality is organized, expressive movement is harmonious and self-consistent, and insofar as personality is unintegrated, expressive movement is self-contradictory" (1, p. 182).

It may well be that clues to the consistency of the psychomotor dispositions of their cases are to be found in the age and integrated personality of their subjects. Their subjects were from 18 to 50 years old and, presumably, were sufficiently mature to have organized personality patterns.

Support for the area factor was also found in the results of Eisenberg's (2) study of dominant and non-dominant persons. The subjects were undergraduate students who had been carefully screened by a questionnaire to select the ". . . *extremely* dominant and non-dominant" (2, p. 23, emphasis mine). It would appear in this study that the factor of age and maturity of personality integration could also well account for the findings of constancy in the area factor.

Early evidence supporting the reliability of the area factor in space covered and number of words spoken was found in Marston's (5) study. He used 100 children between the age of two and six years. Their IQ's ranged from 82 to 158. It was noted that "The outstanding fact is the intellectual superiority of these children who come largely from homes of the university community" (5, p. 19). Not only were his subjects intellectually superior but rating scales in the hands of psychologically trained raters who knew the children "quite intimately" (5, p. 27) were used to select introverted and extroverted children. Children appear to have been selected for the experiment who were generally intellectually far superior to the average child and whose personality characteristics were already clustered about the nucleus of introversion and/or extroversion.

The failure of the present study to yield more clearly positive results may be an outcome of the fact that the subjects were selected so as to exclude contrasting extremes. The findings are in line with those of Jersild (3) who

reported low constancy in behavior, attributed to the influence of particular environments. Wolf (8) also found little evidence of behavioral constancy, in tasks involving no incentives beyond those of the task itself.

Conclusions

Twenty normal children ranging in age from four to twelve years were used as subjects. They were given three one-hour individual nondirective play sessions. Half the children were asked to draw the picture of a person before each play period and half drew immediately after each period. The following week the time of drawing was reversed. Verbatim style records were kept of the child's conversation and activities in the play room. The route they traversed was marked on a scale drawing of the play room.

The nine records (three from each session) of each child were then related by means of the W statistic. The number of words the child spoke, the extent of the area he covered in the play room, and the size of the human figure drawing were compared for reliability.

It was found that each of the subjects used space in an inconsistent manner. The tendency for these results to emphasize specificity may be related to age factors (immaturity in personality organization) and also to the fact that at these ages an attempt was made to choose "average" subjects, excluding extremes within a normal range.

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STUDIES OF GROUP TENSIONS: III. THE EFFECT OF PARENTAL DISCOURAGEMENT OF PLAY ACTIVITIES UPON THE ATTITUDES OF WHITE CHILDREN TOWARD NEGROES[1]

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In a previous study (1) it was shown that questionnaires designed to elicit attitudes toward Negroes yielded scores indicative of only slight agreement between white parents and their children. These questionnaires were administered individually by trained interviewers to parents in their homes and to children in a school conference room. It has been established that the questionnaire submitted to adults had a high degree of validity (2). Voluntary comments made by parents permitted three types of analyses which supplemented each other in yielding the measures of validity. The children made so few voluntary comments that the methods applied to the adult questionnaire could not be used to establish the validity of the children's questionnaire. This report, however, strongly supports the assumption that the replies made by the children were given frankly and in a manner which reflected their attitudes toward, and their communication with, Negro children.

The family often has been said to exert a great influence upon the formation of children's attitudes toward other institutions and their constituents. Underlying this kind of generalization is the assumption that the forces induced by the family, and particularly by the parents, operate consistently through admonitions, prohibitions, and concrete examples to mark out plainly what kinds of conduct are acceptable in children. Undoubtedly with respect to some institutions, parents regulate the learning situations of their children to secure conformity to their own adult roles in society. Inquiries into political and religious affiliations, for example, have yielded moderate positive correlations between the attitudes of parents and children. Is it not possible, however, that husbands and wives who hold opposed or even ambivalent attitudes toward so-called minority groups will subject their children to conflicting reinforcements; moreover, is it also not likely that other parents may even forego an educational role in the hope that

[1] This is one of a series of studies on the broad problem of social responsibility being conducted in the Laboratory for Research in Social Relations, University of Minnesota, under a grant from the Carnegie Corporation.

their children, in some indefinite manner and at an age before early maturity, will develop attitudes similar to the majority of in-group adults around them? Under such conditions, the family would still hold a position of prominence among institutions serving to establish basic attitudes in children, but instead of being one with all of its forces directed toward a clear-cut goal—in this case, that of inculcating in children a consistent set of attitudes toward Negroes—it would be one presenting conflicting forces and conflicting goals. Low correlations between the attitudes of parents and children are just as challenging as high correlations. We have to proceed beyond association to the teasing out of variables underlying the presence or absence of particular kinds of conduct.

Mothers and fathers who hold widely different and sometimes diametrically opposed evaluations of Negroes cannot be expected to have children who resemble either parent to a marked degree. Furthermore, if different standards or value systems than those represented by parents have been incorporated by older siblings, younger children in the family are not likely to escape the impact of them. When children, through contacts with playmates, learn that it is, or is not, positively rewarding to treat other children as potential friends until specific incidents confirm or deny the expectation, the consequences may be the establishment of attitudes sometimes congruent with the instruction of parents and sometimes opposed to it. Where clear and repeated pronunciations are persistently reinforced by parents in a variety of situations, we can expect their children to introject admonitions and prohibitions until there emerges a close agreement between all concerned in attitudes and executive functions. Inquiry into the origin and development of attitudes toward groups differing in racial or cultural origin has not proceeded far enough to enable us to measure the impact of the above and other forces upon children in a satisfactory manner. In the sample of white children under review, we can show that the establishment of attitudes toward Negro children does not always take place under conditions of consistent reinforcement, since parents are not always in agreement with each other about the kind and amount of communication they will permit their children to experience, and the children frequently disagree with one or both parents regarding the discouragement of contacts with Negro children.

The correlations between the scores on two questionnaires, administered to white parents and their children were: fathers-sons +.36; fathers-daughters +.05; mothers-sons +.16; and mothers-daughters +.24. The correlations between fathers and sons, and between mothers and daughters, are statistically significant, but the other two correlations are not. There is more agreement between the scores of fathers and sons than between the scores of fathers and daughters, and this difference is statistically significant. The difference in resemblance of mothers and daughters and of mothers and sons is not statistically significant. The magnitude of these relationships,

however, suggests a multiplicity of forces exerted in different directions, even though there is a hint of forces within the family producing more resemblance than disagreement in attitudes toward Negroes. Since the scores on the questionnaire, administered to mothers and fathers separately, correlated +.52, it may be assumed that, within a considerable number of families, disagreements among parents regarding the kind and amount of communication considered desirable for white and Negro children played a part in creating conditions underlying the low correlations between the scores of parents and children. It is the main purpose of this study to examine the preceding assumption and to present evidence relating to it.

Both of the questionnaires contained items designed to find out if parents and children agreed with one another about prohibitions directed toward the interaction of white and Negro children. The children were asked: "Have you ever been told at home not to play with any of these children: Japanese, Jews, Negroes, Indians, Whites?" If the answer was "Yes," the child was then asked: "By your mother? By your father?" Parents were asked: "Have you discouraged any of your children from playing with, or going with, children in any of these groups: Japanese, Jews, Greeks, Negroes, Indians, native-born whites?"[2] If the answer was "Yes," the group, or groups, named and the sex and name of the child who had been discouraged were recorded. Parents who answered the question negatively were asked: "Then you would be pleased to have your child play with all of these groups?" Although it may be assumed that a negative reply does not designate a particular group, the question aroused defensive attitudes that led to the naming of Negroes. This question was included because it was believed some parents would not explicitly warn a child against playing with Negroes, or would not knowingly and openly admit prejudice, and yet would entertain reservations about being pleased to encourage contacts with all groups of children. Reservations of this sort may not be indicative of clear-cut or strong prejudice, but they do not indicate freedom from prejudice. Our data support the assumption that parents who say they do not discourage their children from playing with, or going with, Negro children, but do not find pleasure in permitting children to choose their own friends, are markedly ambivalent in racial attitudes.

It should be noted that there were different emphases in the form of the questions put to parents and their children. The parents were asked if they had *discouraged* play activities with members of six groups of children, whereas the children were asked if their parents had *told* them not to play with members of five groups of children. We had planned to ask parents if they had told their children not to play with children of different racial

[2] It is recognized that the designation "native-born whites" includes members of groups already referred to in the question. Only a few of the respondents noticed this fact and they were informed of the difficulty faced in trying to delineate specific features of any racial or cultural group.

origin, so that a direct check upon agreement between parents and children could be made. Since the inquiry could not be made without the consent of several committees from two districts, and consent was not obtained to use the more direct form of question, we compromised by asking adults if they had discouraged interracial play activities.

Discrepancies within families, such as a parent saying he has discouraged interaction with Negro children and a child saying he has not been told to avoid playing with them, may be explicable in terms of the connotations of the two forms of the questions. There were parents who admitted they would not openly forbid a child to play with Negroes but that they would try in subtle ways to make known their disapproval. When, however, children say they have been told not to play with Negroes and parents say they have not discouraged such interactions, the discrepancy cannot be explained by differences in the form of the questions.

There were 152 white children in the sample selected for investigation. They were enrolled in the third, fourth, and fifth grades of two public schools. The mean age of these children was 9.35 with a standard deviation of 1.03 years. In both schools, and in each of the three grades, Negro children were also enrolled.

It was possible to interview 272 parents representing 145 families. A family was considered complete when both parents were interviewed, or when only one parent, as the head of the household, could be interviewed. There were instances where death, divorce, or separation made it necessary to regard the family as a complete unit under the direction of a mother or a father. Of these broken families, one was under the care of a father and 17 under the care of mothers. The number of unbroken families, therefore, was 127.

The 272 mothers and fathers made scores on their questionnaire ranging from 7 to 31, the mean score being 18.14 and the standard deviation 6.19. High scores denote more favorable responses to Negro people than do low scores. The mean score of 144 mothers was 18.27 ± 6.09, and the mean score of 128 fathers was 18.08 ± 6.34. As groups, men and women did not differ significantly in racial attitude.

Scores made by the 152 children on their questionnaire ranged from 12 to 30, the mean score being 21.84 ± 4.13. Again high scores are indicative of less prejudice than low scores. As a group, the 72 boys achieved a mean score of 22.71 ± 4.52, whereas the group of 80 girls had a mean score of 20.99 ± 3.82. The girls, therefore, were more prejudiced than boys toward Negroes. The difference between these means is statistically significant at less than the .02 level of confidence.

If we are to estimate the effects of parental discouragement of play activities upon the attitudes of white children toward Negroes, we must portray the disparities in the statements of parents and their children. There are several ways of doing this, because children may say they have been dis-

couraged and parents may say they have not offered discouragement, or children may say they have not been told to limit play contacts and parents may say they have attempted to restrict them.

One way of indicating disparities is as follows: 58 per cent of mothers agreed with their children that no discouragement had been manifested toward intergroup activities, 10 per cent agreed with their children that discouragement had been shown, and 32 per cent were in conflict with the assertions made by their children. Of the fathers, 66 per cent, 11 per cent, and 23 per cent, respectively, are included in the same categories. These percentages do not adequately depict conflicts within families considered as units. If we take into account only the 127 unbroken families, since 64 were represented by both parents and children being in agreement about the absence of discouragement and three families agreed completely that there had been discouragement, conflicting statements relative to the disapproval of play activities with Negro children characterized 47 per cent of complete families.

If we establish as a criterion of prejudice the admission by parents of the discouragement of play activities with Negroes and the admission by children that one or both parents made statements prohibiting such play contacts, then 43 per cent of boys and 50 per cent of girls were subjected in the home to some kind of anti-Negro bias. Only 21 per cent of boys and 23 per cent of girls, who said they had not been told to avoid playing with Negro children, had both parents saying, or the only parent acting as head of the household saying, that pleasure was afforded by having children play or go with all of the groups named in the questionnaire. The balance of the children, 36 per cent of boys and 27 per cent of girls, agreed with parents about the absence of discouragement, but the parents admitted they were not pleased to have their children play with, or go with, Negroes. Comparisons between the percentages of boys and girls in each of these categories yield no statistically significant differences.

By limiting attention to the replies of children, we can determine the effect of extreme parental prohibitions upon children's attitudes toward Negroes. Approximately 24 per cent of the boys and 30 per cent of the girls said their parents had told them not to play with Negro children. The boys who made this assertion had a mean score on the questionnaire of 19.18 ± 4.18 and boys who said they had not been told to avoid playing with Negroes had a mean score of 23.80 ± 4.03. The difference between these mean scores is significant at less than the .01 level of confidence. A similar comparison for girls yields mean scores of 18.92 ± 3.89 and 21.88 ± 3.44, respectively, and again the difference is significant at less than the .01 level of confidence. Outspoken parental reprovals exert a marked effect upon the attitudes of most children, since those who recognize prohibitions tend to be more prejudiced than children who say they have not been the recipients of verbal admonitions.

Boys and girls who say they have been told not to play with Negroes do not differ significantly in prejudice scores; whereas boys and girls who say they have not been told by parents to avoid playing with Negro children differ significantly in mean scores, since the difference between the means of 23.80 and 21.88 has a confidence level of less than .01. We do not know why boys who deny spoken prohibitions should be less prejudiced than girls who also deny them. It may be that parents seek to reduce opportunities for daughters to play with Negroes. Such control is usually less for boys than for girls. Parents who discourage boys and parents who discourage girls apparently go out of their way to curtail contacts with Negro children.

Tables 1 and 2 present in greater detail the extent of agreement between parents and children regarding interracial play activities. The data of these tables project into prominence some of the variables underlying the low positive correlations between the scores of parents and children.

TABLE 1

MEAN SCORES AND STANDARD DEVIATIONS ON QUESTIONNAIRES OF 96 WHITE CHILDREN AND THEIR PARENTS WHEN THE CHILDREN SAY BOTH PARENTS HAVE NOT DISCOURAGED PLAY ACTIVITIES WITH NEGRO CHILDREN

Expressed Attitude of Parents	*Sex of Child*	Children *N*	Children *Mean*	Children *S.D.*	Mothers *N*	Mothers *Mean*	Mothers *S.D.*	Fathers *N*	Fathers *Mean*	Fathers *S.D.*
(A) Mother says she does not discourage and is pleased.	Boys	20	24.35	3.61	19	23.26	4.40	19	21.47	6.00
	Girls	25	21.60	2.90	24	21.38	5.28	24	20.29	6.93
(B) Mother says she does not discourage but is not pleased.	Boys	18	23.50	4.09	16	18.38	5.54	16	18.00	7.06
	Girls	13	20.62	3.36	13	15.38	3.54	13	15.85	4.17
(C) Mother says she does discourage.	Boys	10	21.90	4.30	10	14.40	3.58	10	15.80	3.87
	Girls	10	23.20	4.17	10	15.80	4.58	10	18.50	4.18
(D) Father says he does not discourage and is pleased.	Boys	24	24.38	3.62	21	21.05	5.48	21	23.10	4.99
	Girls	23	21.96	3.49	22	21.23	5.34	22	23.55	4.98
(E) Father says he does not discourage but is not pleased.	Boys	17	22.35	4.59	17	17.18	5.13	17	16.53	5.44
	Girls	17	20.53	3.36	17	17.12	4.65	17	15.24	2.71
(F) Father says he does discourage.	Boys	7	23.43	3.25	7	18.43	5.88	7	12.57	3.70
	Girls	8	23.25	2.54	8	14.13	3.44	8	13.88	4.31
(G) Both parents say they have not discouraged and are pleased.*	Boys	12	25.42	2.96	11	22.82	4.55	11	23.73	4.96
	Girls	14	21.93	2.60	13	23.85	4.15	13	25.76	4.17
(H) Both parents say they have discouraged.*	Boys	4	21.50	3.04	4	15.50	4.27	4	14.25	3.56
	Girls	4	23.50	3.28	4	12.50	1.66	4	13.50	1.80

* Categories G and H include children and parents drawn from categories A and D, and from categories C and F, respectively.

In Table 1 we have assembled the mean scores of 48 boys and 48 girls who said that both parents had not told them to avoid playing with Negro children. The expressed attitudes of the parents are also indicated, as well as the mean scores on their questionnaires. In categories A-B-C, the fathers have had their scores recorded without regard for their own attitudes toward the play activities of their children; and, in categories D-E-F, the attitudes of the mothers have not been taken into consideration. Categories G and H include parents and children drawn from categories A and D, and C and F, respectively. In these families, both parents say either that they have not discouraged free choice of playmates by their children, or they have sought to restrict such choice. It must be recalled, however, that none of the children represented in Table 1 has indicated awareness of outspoken objection to interracial contacts on the part of either parent.

The mean scores of these 96 children are higher, or indicative of less racial prejudice, than the mean scores of children who admit they have been told by parents not to play with Negroes. When mothers or fathers say they are pleased to have their children play with all members of the racial groups named in the questionnaire, their boys attain high mean scores. None of the differences obtained from comparing the mean scores of boys represented in Table 1, however, meets a satisfactory criterion of statistical significance, no matter what position the mothers or fathers have taken regarding interracial play activities. Some of the contrasts between the mean scores of boys and of girls are statistically significant. When mothers are pleased to have their children play with any of the groups named in the questionnaire, the difference in mean scores of boys and girls, category A, is significant at less than the .01 level of confidence. When fathers make a similar assertion, category D, boys again are less prejudiced than girls, since the level of statistical confidence is slightly greater than .02. If both parents say they have not discouraged but are pleased to have their children play with the racial groups named in the questionnaire, category G, the difference in the mean scores of boys when compared with the mean scores of girls also is statistically significant at less than the .01 level of confidence.

A comparison of the mean scores of girls, represented in Table 1, likewise yields no statistically significant differences. It appears from categories B and E that the most effect is exerted upon girls when mothers and fathers say they have not discouraged but they are not pleased to have their children play with Negroes. This again might mean that these parents are using the subtle approach of limiting opportunities for racial interaction.

Since the mean scores of the children included in Table 1 are all higher than the mean scores of boys and girls who said they had been told not to play with Negro children, we may conclude that children are moved in the direction of racial prejudice more by spoken prohibitions than by the subtle forces some parents hope will be effective.

There is no doubt that the avowed attitudes of parents are a good index of their own racial prejudice. Mothers who say they do not discourage but are pleased to have their children play with any of the children named in the questionnaire are far less prejudiced toward Negroes than mothers who express any degree of discouragement. Comparisons between the mean scores of mothers represented in category A with the mean scores of mothers represented in categories B and C yield differences which are statistically significant at less than the .01 level of confidence. The same statement holds true for the fathers, since category D compared with category E, or with F, indicates that permissive fathers are far less prejudiced than those who hold reservations about, or who frankly discourage, their children's play activities with Negroes. Differences between these mean scores are characterized by the same level of confidence as the differences involving the mean scores of the mothers.

Mothers who say they do not discourage interracial play activities and who also say they are not pleased with such interactions, category B, generally, with respect to racial attitudes, are more like mothers who openly admit discouragement, category C, than they are like mothers who find pleasure in having children choose their own friends, category A. The same interpretation holds true for the fathers, categories E and F. Even though the scores of fathers in category E are higher than the scores of fathers in category F, the differences among the means are not statistically significant. The general trend of the parents' scores, however, parallels the expressed attitudes toward the play activities of children. The hierarchy from least prejudiced to most prejudiced aggregates of parents is: mothers or fathers who are pleased with children maintaining interracial play activities, mothers or fathers who do not openly discourage but find no pleasure in such play activities, and mothers and fathers who discourage them, apparently through subtle means not recognized by their children as spoken prohibitions.

The hierarchy of mean scores stands out more clearly if we go beyond the data of Table 1 to include all of the mothers and fathers in the sample under each of the three types of assertions: (*a*) I am pleased to have my children play with all groups, (*b*) I have not discouraged my children but I am not pleased to have them play with Negroes, (*c*) I have discouraged my children from playing with Negroes. The mean score of 61 mothers in category (*a*) was 22.43; of 44 mothers in category (*b*), 16.16; and of 39 mothers in category (*c*), 14.00. The mean score of 51 fathers in category (*a*) was 23.00; of 39 fathers in category (*b*), 15.85; and of 38 fathers in category (*c*), 13.97. The differences in mean scores are significant at less than the .01 level of confidence between (*a*) and (*b*), (*a*) and (*c*), and (*b*) and (*c*) for mothers and for fathers.

Earlier it was pointed out that the scores of mothers and fathers on the questionnaire correlated +.52. Generally, therefore, the mean scores of

parents should resemble each other, even though the expressed attitudes of the mothers, or of the fathers, are not taken into consideration. In Table 1 the expressed attitudes of fathers have been ignored in categories A-B-C, and those of the mothers have been ignored in categories D-E-F. In these categories, with two exceptions, the mean scores of parents are in the expected direction. When mothers say they have discouraged girls from playing with Negroes, category C, the fathers of these girls are not as prejudiced as the mothers. The mean scores of mothers and of fathers, 15.80 and 18.50, respectively, do not differ from each other significantly, in that the confidence level exceeds .20. When fathers say they have discouraged boys, category F, the mothers of these boys are not as prejudiced as the fathers. The mean scores of fathers and of mothers, 12.57 and 18.43, respectively, differ from each other at a confidence level between .05 and .10. Within these two groups of families, not only do parents tend to differ from each other in the amount of prejudice toward Negroes but these mothers and fathers also tend to disagree in their statements about restricting the play activities of children. In only four families did mothers and fathers both agree they had discouraged boys, and in another four the mothers and fathers both said they had discouraged girls from playing with Negro children, category H. The mean scores of these parents are indicative of marked prejudice.

In only 24 out of 127 unbroken families, children said that both parents had not told them to avoid playing with Negroes and both parents said they were pleased to have their children play with all of the named groups. These parents, category G, are among the most unprejudiced ones in the sample. Their sons also are relatively free from racial prejudice but their daughters are only slightly less prejudiced than the typical girl in the sample.

In addition to the 96 children included in Table 1, there were 56 children, 24 boys and 32 girls, who said they had not been encouraged to play with Negro children by both parents. Some of these children evidently could not make reference to the expressed opinions of both parents, since 10 boys and 8 girls had been deprived of their fathers and one girl had been deprived of a mother.

Disagreements regarding the prohibition of play activities among the families represented in Table 2 are many, with the exception of mothers and children represented in category A and the fathers and children represented in category E. Twelve of the thirteen children included in category A were under the sole guardianship of mothers; moreover, these mothers and children expressed agreement concerning the lack of disapproval of play activities. Four boys and four girls also agreed with fathers about the absence of discouragement, category E, but in this category the expressed attitudes of the mothers have not been considered.

TABLE 2

MEAN SCORES AND STANDARD DEVIATIONS ON QUESTIONNAIRES OF WHITE CHILDREN AND THEIR PARENTS WHEN CHILDREN SAY A PARTICULAR PARENT HAS OR HAS NOT DISCOURAGED PLAY ACTIVITIES WITH NEGRO CHILDREN

*Assertion of Child and Parent**	*Sex of Child*	Children *N*	Children *Mean*	Children *S.D.*	Mothers *N*	Mothers *Mean*	Mothers *S.D.*	Fathers *N*	Fathers *Mean*	Fathers *S.D.*
(A) Mother does not discourage; mother says she does not discourage.	Boys	6	25.50	3.59	6	20.17	9.44	0	. . .	. . .
	Girls	7	21.86	3.40	7	18.86	7.06	1	20.00	. . .
(B) Mother does not discourage; mother says she does discourage.	Boys	2	25.00	. . .	2	8.00	. . .	1	15.00	. . .
	Girls	3	19.33	. . .	3	15.33	. . .	2	18.50	. . .
(C) Mother does discourage; mother says she does not discourage.	Boys	12	19.83	4.32	12	18.33	5.85	11	17.00	7.42
	Girls	10	18.60	4.41	10	19.10	3.86	10	16.70	5.48
(D) Mother does discourage; mother says she does discourage.	Boys	4	16.25	2.17	4	16.50	6.69	2	19.00	. . .
	Girls	11	19.82	3.16	10	11.60	2.54	9	13.00	3.20
(E) Father does not discourage; father says he does not discourage.	Boys	4	22.25	.63	4	21.50	4.61	4	26.50	2.06
	Girls	4	19.50	5.03	3	17.00	3.56	4	16.25	3.70
(F) Father does not discourage; father says he does discourage.	Boys	3	18.00	5.10	3	10.67	0.47	3	13.33	2.87
	Girls	7	20.29	2.71	6	12.67	3.77	6	17.50	5.74
(G) Father does discourage; father says he does not discourage.	Boys	1	21.00	. . .	1	27.00	. . .	1	14.00	. . .
	Girls	5	18.00	3.85	5	17.80	5.64	5	17.20	4.79
(H) Father does discourage; father says he does discourage.	Boys	6	19.50	3.15	6	17.00	5.03	6	13.33	3.94
	Girls	8	18.25	4.05	8	15.13	4.83	8	13.38	3.60

* The first assertion is always the one made by the children.

The boys and girls in category A and the boys in category E, who agree with the parent about the absence of discouragement, achieve mean prejudice scores like those of the children, represented in Table 1, who said that both parents had not told them to avoid playing with Negroes. The mothers of these children in category A and the fathers in category E, whose expressed attitudes are stated, also are less prejudiced than most persons in the total sample. Apart from these comparisons, because of the relatively few parents and children in most of the categories of Table 2, it seems more

appropriate to stress the general trend of the mean scores than to deal with contrasts between specific categories.

Earlier we pointed out that boys who said they had been told not to play with Negro children achieved a mean score on their questionnaires of 19.18 and girls who made similar statements achieved a mean score of 18.92. In deriving these mean scores, we ignored the expressed attitudes of parents toward interracial play contacts. A perusal of Table 2 shows that when children select mothers or fathers as discouraging agents, irrespective of the correspondence or lack of correspondence between the assertions of all concerned, the mean scores of children indicate the impact of spoken prohibitions within the family.

The expressed attitudes of the mothers, Table 2, are congruent with the mean scores achieved on their questionnaires. Mothers who admit discouraging children have lower mean scores than mothers who deny taking exception to play contacts with Negro children. Only one group of fathers, whose attitudes have been taken into consideration, those paired with boys in category E, achieve mean scores indicative of little prejudice toward Negroes, since all other fathers have mean scores below the mean of the total sample of fathers, namely 18.08. The general trend of the mean scores of parents representing the unbroken families in Table 2 indicates that their children are not likely to escape the impact of some form of discouragement, including openly expressed criticism.

Of 36 mothers said by 37 children to express openly prohibitions against play contacts with Negroes, 22 deny what their children have said. Of 20 fathers also selected by their children for outspoken opposition toward play activities with Negroes, only 6 deny the assertions of their children. These disagreements within families, and others already reported or implied, call into question the assumption that, with respect to racial attitudes, children are positively or negatively reinforced in a consistent manner.

Summary and Conclusions

The coefficients of resemblance in total scores on two questionnaires submitted to parents and their children were found to be low but positive. Evidence has been assembled to show that there is a great diversity of attitudes among parents regarding Negroes with a consequent subjection of many children to conflicting forces within the home. It has not been claimed that the conditions within the home are the only ones accounting for differences in attitudes between parents and their children. Using as a reference point the agreement or disagreement regarding the limitation of play activities of white and Negro children, we have portrayed families more in agreement than disagreement but disparities have been marked.

Children who say their parents have told them not to play with Negroes are more prejudiced than children who have not been aware of outspoken

restraint. If parents say they have discouraged their children and the children say they have not been aware of either parent making spoken prohibitions, the mean scores of these children usually will not differ significantly from those whose parents say they have not discouraged play contacts. Children, however, will be more prejudiced toward Negroes if they assign conflicting roles to parents, and the parents actually disagree with each other about the discouragement of play activities. Boys are not as prejudiced as girls, except when both boys and girls say they have been told not to play with Negro children. The statements made by children regarding the discouragement of intergroup contacts do not clearly indicate the degree of prejudice manifested by parents. Mothers and fathers, however, are placed clearly in a hierarchy of mean scores indicative of racial prejudice by their own admission of discouraging or encouraging interracial play activities. The attitude expressed by wives, or by husbands, toward limiting play activities of children, is a fairly good indication of the extent of prejudice manifested by their mates.

Considering the implications of all the data, we seem justified in concluding that very few of the families are typified either by vigorous efforts to educate children in democratic attitudes, or by vigorous efforts to inculcate in children strong antipathies toward Negroes. The children in the sample have reached an age when they can incorporate the admonitions of their parents, as is attested to by the differences in prejudice scores between children who say they have and those who say they have not been told to avoid playing with Negro children. The lesser variability of the scores of children, in comparison with those of adults, suggests, however, that children have not yet had their attitudes structured into either strong antipathy or marked liking for Negro children. Parents, with children of the ages in this sample, do not reinforce effectively whatever orientation they prefer their children to adopt.

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PLANS FOR THE CONSTRUCTION OF A PORTABLE ONE-WAY OBSERVATION BOOTH [1]

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One-way observation facilities have been used extensively in research and training settings where the presence of observers in the environment may affect considerably the behavior of the subjects under investigation—in child research institutes, psychological and psychiatric clinics, and teacher training institutes. One-way observation facilities allow for the minimal involvement of observers in the subjects' environment, controlled observation, the free utilization of recording apparatus of forbidding appearance, discussion (where soundproof facilities are available) among observers, and arrivals and departures during observation periods.

Typically, these booths are built on a principle which utilizes a mirror (or painted screen) with a light differential between its two surfaces established by control of light sources. Under normal circumstances, the observer on the dark side, in the booth, sees the mirror as a window, and the subject, on the light side, in the experimental room sees only his own normal reflection. When a mirror is used, the booth usually is soundproofed, with sound transmitted to the observer via some mechanical system. Such booths invariably are built permanently into experimental rooms and have entrances independent of those rooms.

There are numerous occasions when it is desirable to use one-way observation facilities, though those facilities may be unavailable. Often, funds are not available for the installation of permanent facilities. Sometimes, the duration of a project is such that the expense of installation of permanent facilities is unwarranted. Frequently, the problem under investigation may call for the study of groups of subjects from several sources (e.g., children from several nursery schools), at which sources one-way observation facil-

[1] This enterprise stems from a larger study which was supported by a grant-in-aid from the Social Science Research Committee of the University of Chicago.

[2] The writer is grateful to Mr. Israel Goldiamond for the drawings and for several useful suggestions.

ities are unavailable. Only too often in these cases, researchers have been forced to sacrifice some degree of methodological precision.

The present writer has developed a portable, easily dismantled, one-way vision booth for his research purposes which can be constructed feasibly

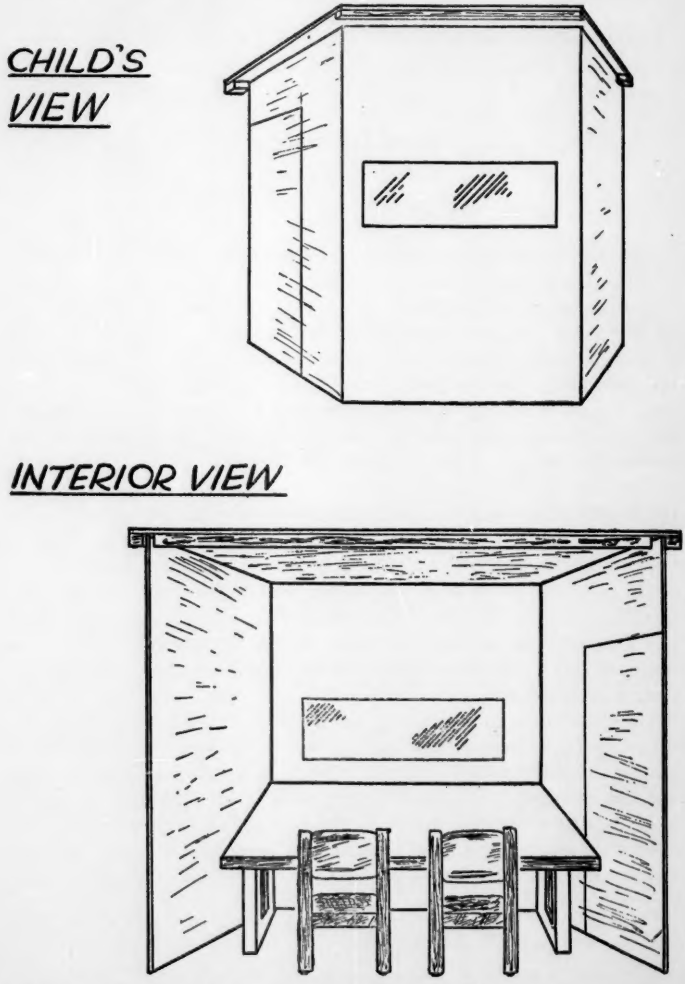

FIGURE 1—The portable room set up, showing interior and exterior views.

and used where one-way observation facilities are unavailable. Though the booth was designed for researches involving children, it can be adapted easily for a myriad of other research ends. Such a booth can be used where research funds are limited, as it is readily constructed of inexpensive materials and can be modified to fit almost any research or training requirement. Should the researcher's needs change, the material components of the booth can readily be salvaged or reconciled into almost any modification of observation facilities appropriate to a given research problem. It is because of the frequent lack of adequate observation research facilities, particularly in nursery schools unaffiliated with child research centers or in pediatric, psychiatric or psychological clinics, and because of the fact that most independent researchers in this area work on rather limited budgets, that the writer believes that the design of this portable observation booth can be of considerable use to workers in the area. The entire booth can be constructed for less than $100.00, depending on labor costs and the availability of inexpensive salvage materials. If labor is not included in the cost, the materials alone, at current prices, should come to about $60.00.

The plans presented in the sections following include a set of exact specifications for a standard booth that can be used under most circumstances. These plans should be taken as suggestive only and there are many degrees of freedom in the plans for those who have different needs. At almost every point in the design, modifications are possible. The writer has found a booth of those dimensions useful in his researches with children. Some of the uses to which the booth has been put can illustrate its flexibility. It was set up on one occasion in a nursery school for use in an experimental study of attention-seeking in young children (2) and on another occasion in a private apartment for use in an investigation of the doll play aggression of a group of selected neighborhood children (1).

Construction Plans

The one-way observation booth, as seen in Figure 1, appears from the outside to be a large closet or workroom independent of the experimental room. Typically, the mirror in the front panel of the booth is accepted by children as belonging in the experimental room. The interior view gives an indication of the distribution of space. The dimensions presented in the plans allow two observers to sit comfortably at the table, though three average-sized observers can do so if necessary. Additional observers can stand or sit elsewhere in the booth.

The three walls of the booth are of one-half inch thick plywood, a thickness which is relatively rigid and resistant to warping. The wall panels adhere to the standard four foot width in which plywood comes. Structural solidity is obtained by the fact that the three walls reinforce each other when hinged, and by the addition of a one-half inch thick plywood roof

which locks the walls into place. The hinges, as indicated in Figure 2, are small door hinges with pins filed down to allow for quick removal. The entire booth can be assembled in ten minutes and can be dismantled if necessary in half that time. To disassemble the room, the hinge pins are pulled out and the panels laid flat.

Front Panel

The front panel contains three main features: a table and supports which hinge so that they lie flat against the panel when not in use, a rectangular opening, and a rack behind the opening, open at the top for insertion of the one-way mirror. Should there be available in the experimental room a shallow table 29 to 30 inches high and 18 to 20 inches deep, and should that be preferred to the table described directly below, none of the additions to the panel, with the exception of the opening and rack, need be constructed. The one-way mirror frame can be supported by the table. The additions to the panel have been included to obviate transporting such a special table.

Table and supports. The table top consists of an 18 x 48 inch sheet of one-half inch plywood hinged on its underside, by means of two strap hinges, to the table-hinge panel (Figure 2). This panel is simply a 1 x 10 inch board. It should be noted that the panel is cut away past the hinges to provide clearance for the table supports. The table supports are essentially frames hinged at their sides directly to the front panel. The odd shapes of the tops of the supports derives from the necessity for their heights to be 29¼ inches at one end to support the table when open and to be less than that height to provide for the lowered ends of the table-hinge panels where these support the table hinges. As illustrated in the upper portion of Figure 2, supports fold flat against the front panel (the hinges are countersunk), and the table top folds flat against these. Obviously, these supports should be constructed of wood equal in thickness to, or slightly thinner than, the thickness of the table-hinge panel. Small grooves in the underside of the table-top will allow the table supports to fit snugly.

Window opening. The dimensions of the window, a rectangular opening cut into the front panel as indicated in Figure 2 are based on the mirror constructed for the writer's purposes. Except for the distance from the bottom of the window to the floor which is the convenient height for viewing when seated, all dimensions given (thickness of the slot in the window frame, height and length of the window) are subsidiary to those of this mirror. Should some other size mirror be available or desired, these dimensions can be altered very simply.

Frame rack for window. The one-way mirror frame slips into this rack from above. The top of the table-hinge panel serves, with an addition, as the support for the mirror frame. The addition is a bevelled piece of wood stretching along its length, and providing, together with the table-hinge

panel, for 1¾ inch clearance on its bevelled side. Two pieces of wood, 1¾ inches thick by the height of the window from the sides, and a narrow board is fastened across at the back of their upper parts. When slipped into the rack thus created, the one-way vision mirror is secure and capable of moving only in the upward direction.

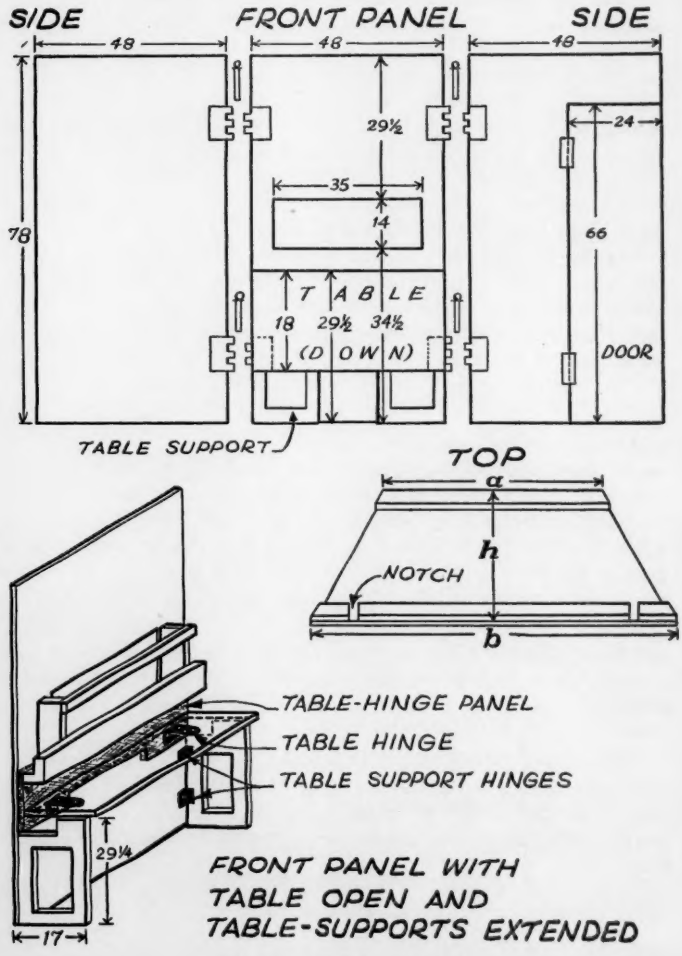

FIGURE 2—Panels and roof.

Side Panels

The left panel (interior view) is untouched except for the attachment of hinges. The right panel contains a small door, with hinges on the inside.

Roof

The top consists of an isosceles trapezoid with two strips of wood screwed to the parallel sides. If side *a* is 54 inches, there will be 3 inches clearance on either side (Figures 1 and 2). The altitude, *h*, and the base, *b*, are thus co-variables, and depend upon the angle one wishes between the side panels and the front panels. The limits, of course, are 180 degrees and 90 degrees. Since the shape of the roof is a variable which depends upon the uses of the booth anticipated by the experimenter, no dimensions for it have been included. It will be noted that there are notches in the strip of wood at the base, *b* (Figure 2). These notches lock the side panels into shape (Figure 1, lower drawing). One solution is to make the trapezoid as large as one conceivably can and to provide for extra matching notches should a decrease in size be foreseen. In this case, the front of the roof would project more as the altitude and angles are decreased. This fact should not cause trouble in work with children in that the roof is well out of reach of any child.

The One-Way Mirror

Mirror. A half-silvered mirror can easily be obtained commercially or can be constructed according to a technique described by Pinneau (3). The cost of the mirror used in this design was approximately $30.00, and was cut from a 20 by 40 inch sheet produced by Libby-Owens-Ford. The side of the mirror facing the subject is protected by a sheet of ordinary plate glass of the same dimensions as the mirror. The observers' side of the mirror also can be protected in this manner, should that be desired.

Frame. The frame is built of four pieces of wood cut from a 1⅞ x 2 inch board. The board is bevelled and the mirror and protective plate glass panes tightly inserted between strips of felt into bevelled grooves in each of the four sides of the frame. These are then permanently joined as indicated.

Carrying case. Three 1¾ x 2 inch boards are joined as indicated, providing the outline of the carrying case. Masonite is screwed onto both edges of the case outline, felt placed along the three edges of the case to prevent rattling and a strap attached for carrying convenience. A strap can be placed over the open end for safety.

General Suggestions

Position. If the booth is set up with its back to a door, freedom of entry and of departure would be possible as would some control over ventilation.

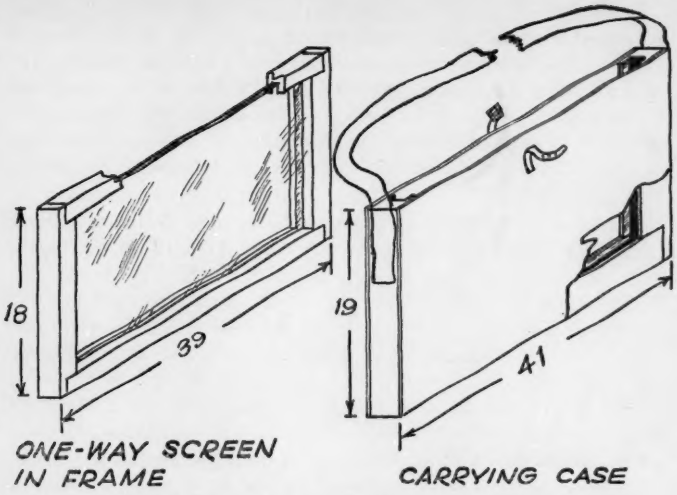

FIGURE 3—Frame for one-way mirror and carrying case.

The booth set-up should take advantage of existing light sources in order that the necessary illumination differential be established for the screen to be seen as a mirror in the experimental room. Portable lamps can easily be set up for this purpose should existing facilities be insufficient. If the booth is to be set up permanently, greater stability can readily be built in. For one, a regular table could be substituted for the table in the design, which would add to the booth's stability and would require less construction labor. If a permanent booth is built against a door, the entry in the side panel may be omitted.

Ventilation. Ventilation holes or screens can be built into the panels or roof. Care should be taken that considerable light does not enter the booth through these holes, since maintenance of differential illumination is all-important for the functioning of the one-way mirror. Setting the booth against a door or window will give some control over ventilation, though it may lead to problems in regard to illumination. An electric fan can be very effective for air circulation and ventilation.

Painting. The outside of the structure may be painted or stained and varnished. The natural grain of plywood can readily harmonize with the fixtures of most rooms and a natural finish may be preferred. The booth's interior is painted a flat black.

Sound passage. The ventilation openings and the general characteristics of the structure allow sound to pass freely in and out of the booth. Sound from the booth may be muffled some by the installation of celotex or cloth

curtains along the interior of the panels. If a fan is used for air circulation, its constant hum will muffle sounds emanating from the booth. One need not be too concerned about the effects of sounds on child subjects. The writer has found that child subjects are minimally disturbed by or interested in sounds emanating from the booth if, in information given them at the start of the observation sequence or in response to their questions about the booth, they are informed that "there are people working in the next room" (the booth).

Miscellaneous. Recording apparatus can be set up in the booth, with the microphones in the experimental room. A roll of tan felt (e.g., one foot in width) effectively can mask the two vertical slits where the panels join. The felt readily can be tacked into place on the interior after the structure has been set up. A light source, built into the booth, can be used for illumination so that work can go on when observation is not in progress. Such a light source can serve also to do away with the light differential if child subjects accidentally happen to look into the booth, and thus prevent them from seeing the purpose of the observation room. Curtains that will cover the inside surface of the screen can be put up to prevent observation from the experimental room of activities in the booth when the internal light source is on. Several trapezoidal roofs of various dimensions can be built for all foreseeable circumstances. Black sateen stagecloth, which is fairly effective in preventing the entry of light, allows ventilation, makes the use of the booth more flexible, and cuts down construction time, can be substituted for the board roof.

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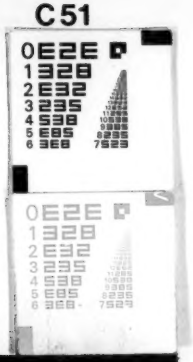
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